

Corrosion

NATIONAL ASSOCIATION OF CORROSION ENGINEERS



YOU CAN *Specify* MINIMUM MAINTENANCE COSTS WITH *Amercoat* PROTECTIVE COATINGS

ONLY AMERCOAT PROVIDES YOU WITH

The most complete line
of corrosion resistant
coatings available anywhere

Field service backed by
an organization SPECIALIZING
in corrosion control

The service life of your equipment—the efficiency of your production schedules — the ultimate value of your investment and maintenance dollars — all are vitally dependent on the continuing performance of the protective coatings specified in your plant. Thus, success or failure of your coatings can mean the difference between tremendous losses or substantial savings.

To assure coating performance that provides long-lasting, low-cost protection, two steps are absolute essentials, right from the start. You need the right coating for each specific exposure, and it must be applied properly if it is to yield maximum benefit.

AMERCOAT ELIMINATES THE GUESSWORK—MINIMIZES MAINTENANCE COSTS

First of all, AMERCOAT provides the right coating for the particular problem. From the complete AMERCOAT line, it is possible to provide specific coatings for specific exposures to achieve specified protective performance.

In addition, you receive the added value of AMERCOAT's conscientious service follow-through backed by an organization SPECIALIZING in industrial corrosion control. With the assistance and on-the-spot advice of a trained representative, you get the best possible application through proper attention to surface preparation and correct coating techniques.

Investigate AMERCOAT now. It's your surest way to effective, long-term corrosion control. An experienced representative is near you to serve you. For complete details write today.

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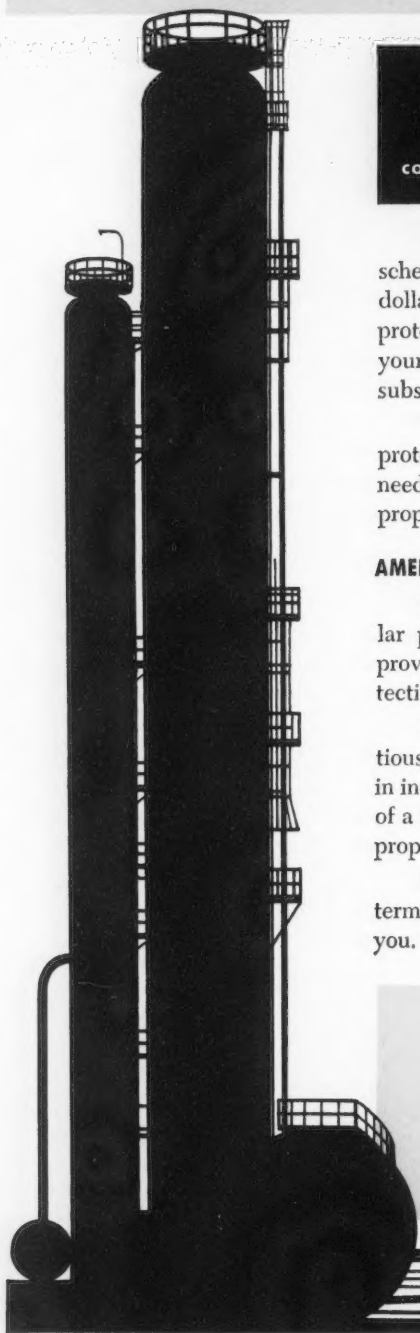
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CORROSION

NEW PROTECTIVE COATING CHEMICAL FOR ALUMINUM

ALODIZING

Alodizing with "Alodine,"* a new technique in the protective coating of aluminum, was made available for production-scale use in 1946. Since that time Alodizing has largely supplanted the more elaborate, costly and time-consuming anodic treatments in the aircraft and other industries.

Continuous and successful industrial use has clearly demonstrated the simplicity and economy of the Alodizing process as well as the effectiveness of the "Alodine" amorphous coatings, particularly as a base for paint. In fact, the paint-bond that Alodized aluminum provides has been found to be superior to that possible with chromic acid anodizing.

The corrosion-resistance of unpainted aluminum Alodized with "Alodine" Nos. 100 or 300 is excellent, easily meeting the requirements of Specification MIL-C-5541. However, a need for protection of unpainted aluminum, even better than that obtained with chromic acid anodizing, has long been recognized.

NEW IMPROVED "ALODINE" DEVELOPED By ACP RESEARCH CHEMISTS

Several years of intensive research have now led to a new type of "Alodine," designated as "Alodine" No. 1200. This new protective coating chemical forms an amorphous mixed metallic oxide coating of low dielectric resistance that provides unusually high corrosion-resistance for unpainted aluminum. In addition, it forms an excellent paint bond that approaches closely the high quality obtained with the earlier types of "Alodine."

After having been tested for conformance with Specification MIL-C-5541, "Alodine" No. 1200 is now about to go into production.

PROCESS DETAILS

"Alodine" No. 1200 is the only essential chemical needed to prepare the coating bath and the final rinse bath. One of its unique features is that it can be used in tanks in an immersion process, or, in a multi-stage power washer in a spray process, or, with a slight adjustment of pH, with brush or portable spray equipment in a manual process. This means that even where the simple production equipment is not available, or where touching up of damaged coatings previously Alodized or anodized is required, excellent protection and paint bonding can still be obtained with practically no equipment.

*"Alodine" Trade Mark
Reg. U. S. Pat. Off.



AMERICAN CHEMICAL PAINT COMPANY

General Offices: Ambler, Penna.

Detroit, Michigan

Niles, California

Windsor, Ontario

All three methods of application easily meet the requirements of Specification MIL-C-5541.

Process sequence for all three methods of application is the same as for other standard grades of "Alodine" such as Nos. 100, 300, and 600, viz.: 1. Pre-cleaning. 2. Rinsing. 3. Alodizing. 4. Rinsing. 5. Acidulated rinsing. 6. Drying.

Coating time in an immersion process ranges from 2 to 8 minutes and in a mechanized spray process is about 30 seconds. "Alodine" No. 1200 baths are operated at room temperatures (70° to 100°F.) and heating is required only if the bath has gotten cold after a "down" period.

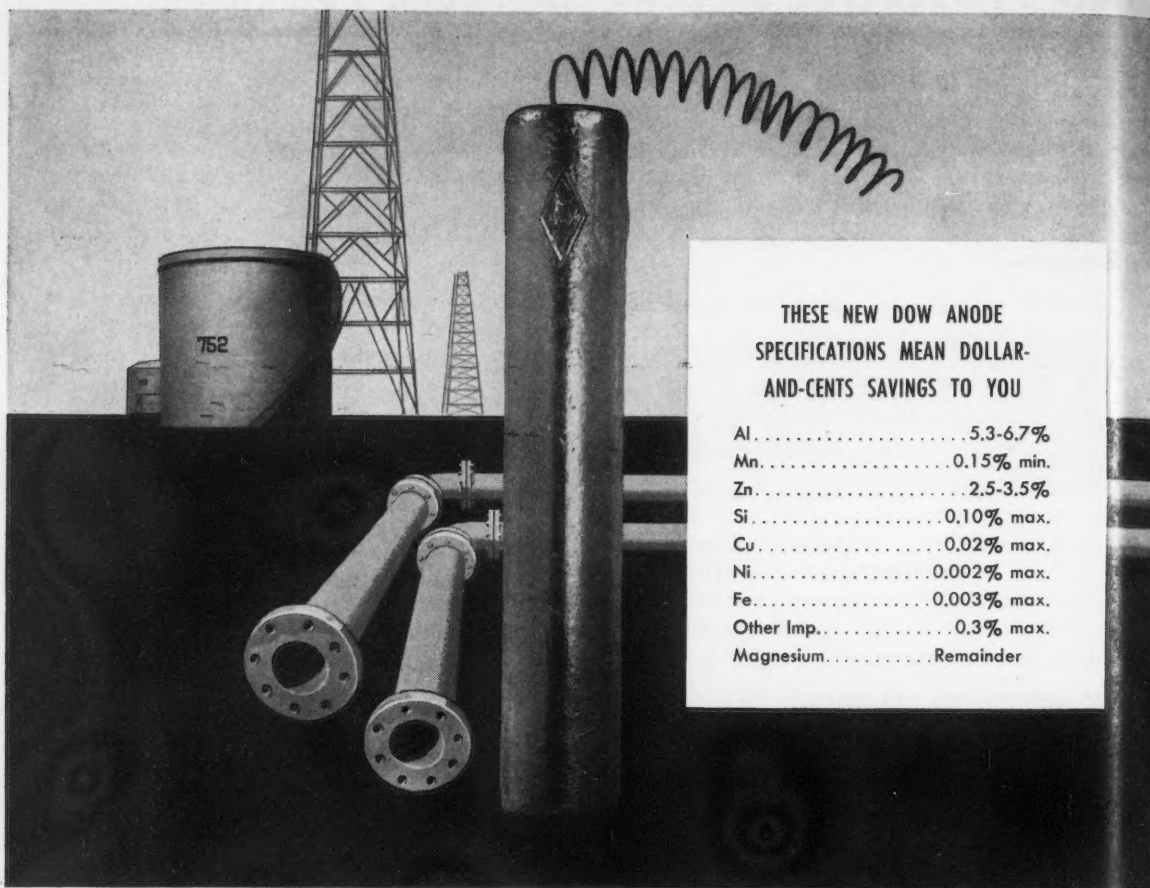
RECOMMENDED USES FOR "ALODINE" No. 1200

"Alodine" No. 1200 is specifically recommended for coating wrought products that are not to be painted or are to be only partially painted; and for coating casting and forging alloys whether or not these are to be painted. "Alodine" Nos. 100 and 300 are still recommended for coating wrought products such as venetian blind slats, awnings, etc., that are invariably painted.

RESULTS OF TENSILE TESTS

This new "Alodine" not only retards visible corrosion and pitting, but as shown in the table below, the loss of ductility with "Alodine" No. 1200, both brush and dip, after 1000 hours salt spray was less than for chromic acid anodizing after 250 hours, and for "Alodine" No. 100 and a conventional chromate treatment after 168 hours exposure.

PROCESS	SALT SPRAY EXPOSURE	COMPLIANCE WITH TENSILE REQUIREMENTS OF MIL-C-5541
CHROMIC ACID ANODIZING	168 hrs. 250 hrs. 500 hrs. 1000 hrs.	passes passes fails fails
BRUSH "ALODINE" No. 1200	168 hrs. 250 hrs. 500 hrs. 1000 hrs.	passes passes passes passes
DIP "ALODINE" No. 1200	168 hrs. 250 hrs. 500 hrs. 1000 hrs.	passes passes passes passes
DIP "ALODINE" No. 100	168 hrs. 250 hrs. 500 hrs. 1000 hrs.	passes fails fails fails
CONVENTIONAL CHROMATE TREATMENT	168 hrs. 250 hrs. 500 hrs. 1000 hrs.	passes fails fails fails



THESE NEW DOW ANODE
SPECIFICATIONS MEAN DOLLAR-
AND-CENTS SAVINGS TO YOU

Al.	5.3-6.7%
Mn.	0.15% min.
Zn.	2.5-3.5%
Si.	0.10% max.
Cu.	0.02% max.
Ni.	0.002% max.
Fe.	0.003% max.
Other Imp.	0.3% max.
Magnesium.	Remainder

New high purity Dow Magnesium Anodes give you more hours of cathodic protection per dollar than any previously available

Cost of cathodic protection is now sharply reduced, thanks to new high purity Dow magnesium anodes. Because common impurities that cut efficiency have been greatly diminished, the new Dow anodes last far longer and give you more ampere hours of protection.

That means less frequent replacement—major savings in labor as well as in the anodes themselves.

Dow's new specifications for high purity magnesium anodes result from some 1,200 individual anode efficiency tests, covering more than 120 batches of magnesium alloy. Ample field testing, under varied conditions, has

proved the findings of the Dow magnesium laboratories. Now available in the complete range of shapes and sizes of cast anodes, the new high purity anodes represent another important step in Dow's continuing program of magnesium research and development.

If you have an underground corrosion problem, Dow magnesium anodes offer the truly dependable solution—unaffected by power line failure or dried-up ground beds. Phone your nearest Dow sales office or distributor of Dow anodes for full details. THE DOW CHEMICAL COMPANY, Midland, Michigan, MA 314K.

you can depend on DOW MAGNESIUM ANODES



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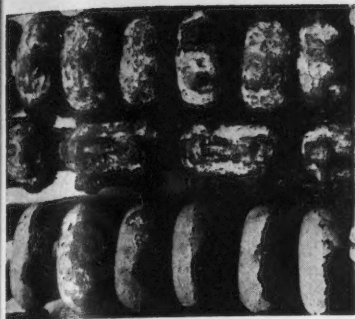
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THIS MONTH'S COVER—Shown here is the effect of protecting with an aluminum powder-plastic vehicle coating cooling sections exposed to contaminated salt water. The coated lower row is shown to be virtually unaffected after two years' exposure while the upper uncoated row has been severely affected. Coated cooling coils were made by The National Radiator Company, Johnstown, Pa., and the coating by Emjay Maintenance Engineers, Rutherford, N. J.



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Foreign remittances should be by international postal

or express money order or bank draft negotiable in the

U. S. for an equivalent amount in U. S. funds. Entered

as second class matter October 31, 1946, at the

Post Office at Houston, Texas, under the act of March

1, 1879.

Corrosion Is Indexed Regularly by Engineering Index.

Corrosion

devoted entirely to
CORROSION
research and control



Published Monthly as its official journal, by the National Association of Corrosion Engineers, Inc., at Houston, Texas, U. S. A., as a permanent record of progress in corrosion control.

Vol. 10

March, 1954

No. 3

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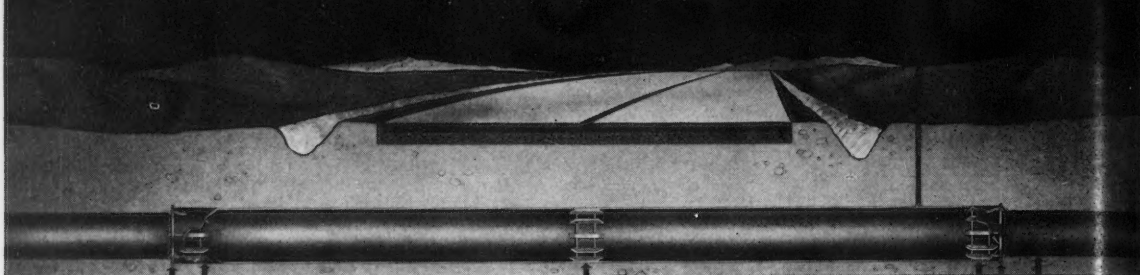
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News reports on activities of regions, sections and other subdivisions of the National Association of Corrosion Engineers should reach Central Office NACE before the tenth of the month, preceding the month in which the report is to be published.

• Secretaries who do not already have a supply are invited to ask for copies of the form "News Report for Corrosion" which facilitates making reports on meetings. Notices of future meetings will be carried in the "NACE Calendar" in the News Section when information is provided in time.

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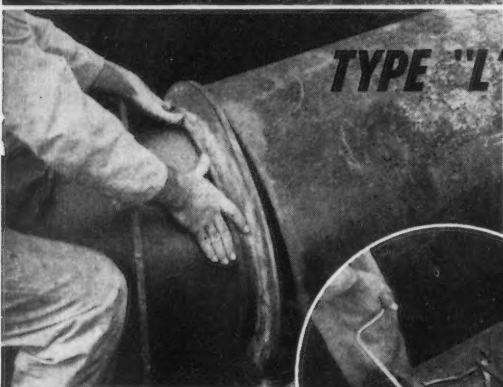
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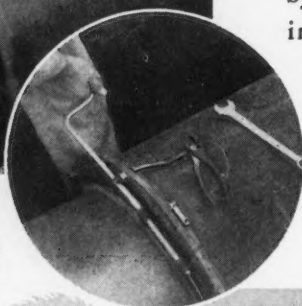


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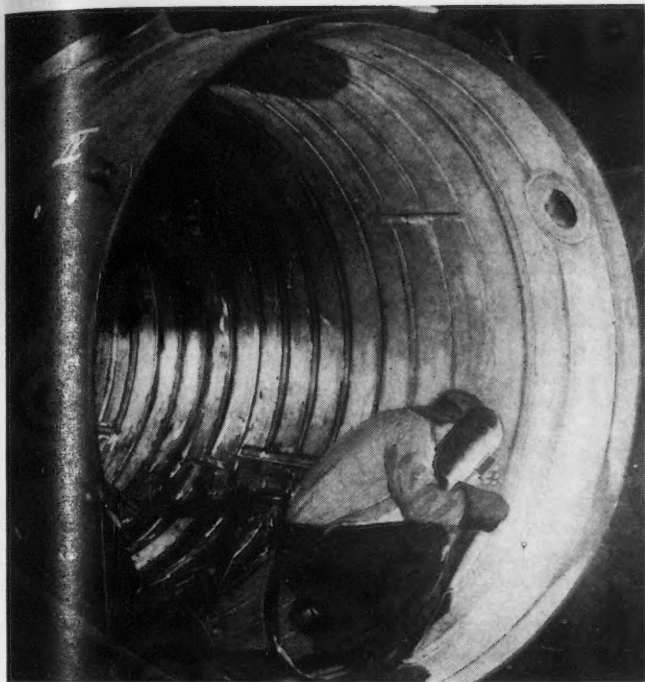
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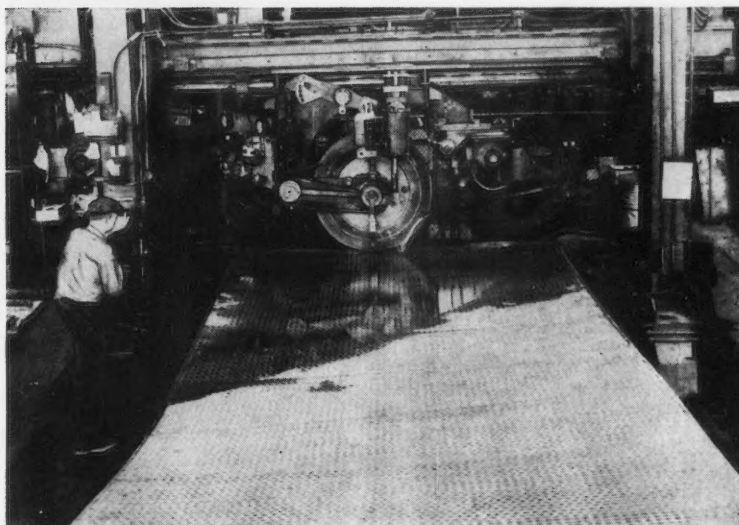
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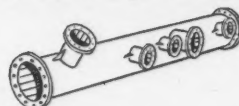
TP-18B *Internal Corrosion of Products Pipe Lines*. Ivy M. Parker, chairman, Plantation Pipe Line Co., Box 1743, Atlanta, Ga. Raymond Hadley, chairman, Sun Pipe Line Co., 1608 Walnut, Philadelphia 3, Pa.

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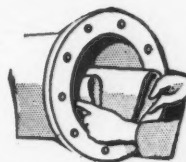
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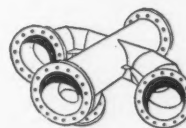
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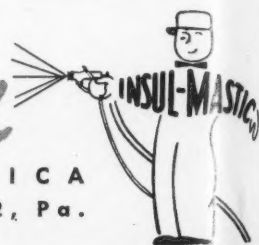
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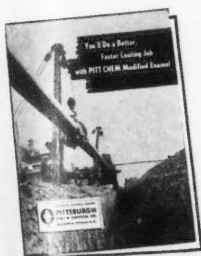


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- (d) To correlate study and research on corrosion problems among technical associations to reduce duplication and increase efficiency.
- (e) To promote standardization of terminology, techniques, equipment and design in corrosion control.
- (f) To contribute to industrial and public safety by promoting the prevention of corrosion as a cause of accidents.
- (g) To foster cooperation between individual operators of metallic plant and structures in the joint solution of common corrosion problems.
- (h) To invite a wide diversity of membership, thereby insuring reciprocal benefits between industries and governmental groups as well as between individuals and corporations.

It is an incorporated association without capital stock, chartered under the laws of Texas. Its affairs are governed by a Board of Directors, elected by the general membership. Officers and elected directors are nominated by a nominating committee in accordance with the articles of organization. Election is by the membership.

Inquiries regarding membership, and all general correspondence should be directed to the Executive Secretary at the administrative headquarters of the National Association of Corrosion Engineers at 1061 M & M Building, No. 1 Main Street, Houston 2, Texas.



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A Statement by the Association's President

NACE Continues Its Healthy Growth

By WALTER F. ROGERS*

AS PRESIDENT of NACE for 1953-1954, the close of my term of office is fast approaching. It is usual in such cases to review in retrospect the events which have transpired, to judge whether in the main, satisfactory progress has been made and postulate the immediate and long term goals. I am happy to report that NACE continued its healthy growth during the year. This continued growth and its multitude of major accomplishments have been the result of the valiant efforts of many individuals at all levels of the society's activities.

Almost without exception, gains have been made all along the line. Our most important asset is our members and in this respect the active membership showed its usual increase. A total of 615 active and 19 junior members were added to the rolls during the calendar year. This brought the total active membership to 4096 as of December 31, 1953.

Perhaps the only respect in which the organization has not shown the desired growth is in the number of corporate members. A gain of 19 was made during the year to bring the total to 381. This was somewhat below the goal set by the Board and presents a challenge which is being met by the organization. Complete plans were made by the Board at the March 1953 meeting to formulate corporate and active membership committees at the Regional and Sectional level. These committees went into action during the early Fall and are now earnestly at work. It is believed that this mechanism presents the best basic plan for increasing all grades of membership and will be given a long term trial.

The growth of the organization is further shown by the increase in number of Sections during the year. On January 1, 1953 five regions with 26 sections were operating. The sixth region, the Canadian, was officially inaugurated at Chicago during the 1953 annual conference, although the preliminary details had been worked out during the previous year. This region now has a total of four sections and others are in process of formation. The other

regions have likewise been active in the formation of new sections. In all, as of January 1, 1954, a total of 37 sections in the six regions have been formed and are functioning. At least six to ten more are in process of formation. This increase is satisfactory numerically but is of greatest importance through the fact that it represents growth at the basic level where organization counts.

Regional meetings increased in importance during the year. Next to the section meeting, the regional meeting is the member's most important opportunity to attend and participate in the work of the Association. During 1953 four of the regions held at least one technical meeting and two of these held two each. The largest of the regional meetings continues to be that of the South-Central Region. This was a three day meeting with a registration of 503. The Western Region held a two day meeting with a registration of 164. The two North East meetings were of one day each with 195 registrants. The South East Region held two one-day meetings with a registration of 123. It is my feeling that these regional meetings are second in importance only to the national meeting and the holding of at least one annual technical meeting in each region is to be encouraged.

The Association is completing a major undertaking in re-vamping the Technical Practices Committee. This change in organization was made necessary by the growth of the work being done by these committees which was resulting in an unwieldy structure. The reorganization is designed to reclassify the committees into industry functional groups. The reduced number of main committees permits the governing technical committee to be composed of a workable number of members. In addition to the reorganization which was announced in the January 1954 issue of CORROSION and becomes effective March 18, 1954, a procedure manual covering the formation procedures, responsibilities and authorities of these committees has been prepared. This manual has been carried in full in CORROSION. As a further means of strengthening the work of the technical committees

* Gulf Oil Corp., Houston, President of the National Association of Corrosion Engineers.

the Association is planning on obtaining a full time secretary for the technical committee work.

While the technical work of the Association is growing rapidly, there are still some facets of it which the society has not yet been able to prosecute as diligently as it hopes to in the future. This is the sponsoring of specific research projects in colleges and research institutions. Such projects require extensive financial resources. These are available from various foundations' funds for such projects but it still remains for NACE to determine those corrosion projects which are sufficiently worthy of research to warrant requesting funds for them.

The Education Committee has cooperated with a large number of universities to give short courses on corrosion subjects. Attendance at these courses has consisted of both members and non-members of NACE. In every case, however, the registrant has a definite interest in corrosion. While these courses are not run by NACE, the society has both a duty and opportunity in cooperating with the sponsoring body to see that the speakers, the subject matter and the ultimate success of the course is to the credit of corrosion engineering and that the net result is the dissemination of correct and useful information on the causes and prevention of corrosion. The Association further has a very selfish interest in these courses for they provide a means of membership growth. The Education Committee has one of the great responsibilities of the organization, for within this group lies one of the greatest possibilities of furthering the aims of the society, one of which is "to promote the prevention of corrosion, thereby curtailing economic

waste and conserving natural resources." The short courses during the year were held at six universities. These were the Universities of California, at Berkeley and Los Angeles, Wisconsin, Illinois, Oklahoma and Texas A & M.

The national meeting is always one of the major annual events of the society. At it the best technical program obtainable is presented, the opportunity exists for all technical committees to meet, the staff committees plan their future work for the year, and the manufacturers exhibit their corrosion preventive measures. The meeting in Kansas City, March 15 to 19, 1954 promises to continue the success of the preceding meetings. An excellent technical program has been arranged and more exhibit space will be presented than at any previous meeting.

Last but not least are the thanks due the national office for the excellent and efficient way in which it has handled the ever increasing work load. As the Association grows in membership and as the members increase their activity in the Association, so does the work of the national office, which must keep the flow of work moving in a steady uninterrupted stream. This is no small task and the efficient way in which our Executive Secretary and his staff perform their duties is a matter in which the members should take pride.

In closing, I feel that the year has been a successful one for the Organization and that progress has been made. I wish for my successors the same helpful spirit from the members which I received, and I know that as long as this continues we will have a strong and useful Association.

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Effect of Operating Conditions on Corrosion Of Hot Water Piping in Buildings*

By HENRY L. SHULDENER

THE USEFUL life of piping systems in buildings is influenced not only by the character of the water and its corrosiveness^{1,2} but by certain other factors, namely, the design and fabrication of the system and its operating conditions.

It is now generally accepted that there is no one kind of pipe which is the universal answer to the problem of corrosion by fresh water.³ However, there is usually a preferred kind of pipe for a particular water supply. Enlightened practice today utilizes local experience and the services of a corrosion engineer before making a decision as to the kind of pipe to use. Municipal water departments generally are not concerned with the corrosion of pipes in buildings but the problems and complaints arising from such corrosion are now demanding their attention.^{8,9}

Whatever the final choice of pipe, be it galvanized iron, galvanized steel, brass or copper, operating conditions are sure to influence corrosion rates. A striking example of the effect of operating conditions on the life of hot water galvanized piping systems in New York City is afforded by the case of two buildings constructed at approximately the same time in the same area and supplied with the same water. One was a hotel and the other an apartment building. The apartment house system required major replacements within ten years because of clogging and consequent poor flow, whereas the hotel system remained in excellent shape. The reason for this puzzling situation, which led the owners of the apartment house to condemn the quality of the pipe installed in their property, was simply the difference in operating conditions.

In the case of the hotel, hot water was furnished 24 hours a day, and temperatures and circulation were thermostatically controlled. In the case of the apartment building, hot water was furnished for only about 16 to 18 hours daily, with no thermostatic controls. In addition the temperature of the water was permitted to fall during the night. The breathing of the piping system due to the large variations of temperature caused flaking off of rust films and consequent exposure of fresh surfaces to continuous corrosion.

Control of the Hot Water Temperature

One of the most important considerations affecting the life of piping systems in buildings is regulation of hot water temperature, which should be held within the range desirable for normal domestic sup-



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Abstract

The useful life of hot water piping in buildings is influenced not only by the character of the water circulated, its potential corrosiveness and scale forming properties and by the piping material but also by a group of factors which may be called operating conditions.

Affecting operating conditions significantly is the design and fabrication of distribution systems.

An understanding of these factors will make improved service and longer pipe life possible.

Faulty hot water circulation creates a number of problems including fluctuating temperatures which frequently leads to overheated water and consequently to accelerated corrosion and to joint leaks caused by excessive expansion and contraction strains.

Modern hot water generation and distribution involves control devices such as aquastats and mixing valves which the building superintendent ordinarily is not sufficiently experienced with to adjust and maintain. Improper maintenance causes many pipe systems to be ruined by excessively high water temperatures. Proper design, maintenance and operation which produces an adequate supply of circulated hot water at the proper temperature not only saves wasted fuel and water but helps to prevent clogging by sediment and the products of accelerated corrosion.

ply in apartment houses, hotels and office buildings. This range is between 130 and 140 degrees F. Heating the water beyond that point increases its corrosiveness materially. Excessively high temperatures cause reversal of potentials in galvanized pipe⁴ resulting in accelerated pitting and also, rapid dezincification of yellow brass piping⁵ as well as pinhole pitting in copper tubing. Moreover, high temperatures magnify the expansion and contraction strains that contribute to the starting of leaks at screwed connections. The means used to control the temperature will depend on the way the water is being heated.

Figures 1 and 2 show hot water heating arrangements most commonly used in larger buildings. Figure 1 shows the water being supplied from a storage tank heated by steam taken from the steam boiler.

*A paper presented at the Ninth Annual Conference, National Association of Corrosion Engineers, Chicago, Ill., March 16-20, 1953.

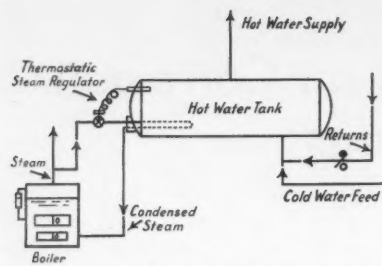


Figure 1—Tank heated by steam coils.

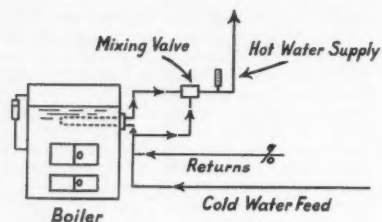


Figure 2—Instantaneous heater.

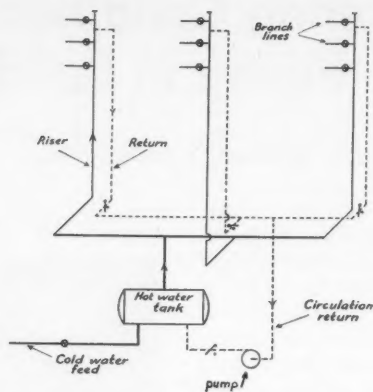


Figure 3—Direct feed with return line for each riser.

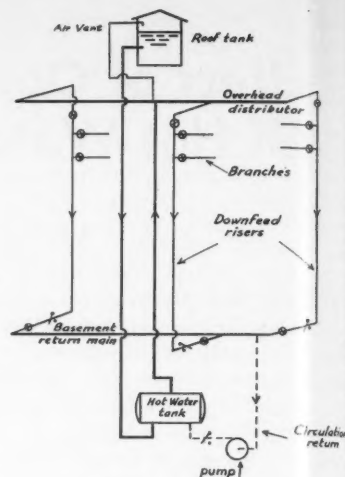


Figure 4—Overhead feed.

The flow of steam to the heating coil in the tank is regulated by a thermostatically controlled valve on the steam line and this valve is actuated by a thermostatic element immersed in the water near the top of the tank.

Figure 2 shows a method of providing hot water that has come into wide use in recent years. It consists of an instantaneous heater immersed in the water in the steam boiler. Cold water passes through this heating coil where it is usually heated beyond the desired temperature and then passed through a mixing valve or blending valve, through which cold water also flows. An expansion element in the valve operates to control automatically the flow of cold water so that the final mixture has a temperature of 130 or 140 degrees F, or whatever temperature the valve is set for. If there are large radiation losses between the heater and the faucets the temperature of the water entering the system is set a little higher.

When a non-scaling water supply is being used, the section of piping between the heater discharge and the mixing valve should be of red brass (even though the remainder of the system may be galvanized iron or steel) because that particular section will usually have to withstand the 180 to 200 degrees F temperature developed before tempering in the mixing valve.

Instantaneous heaters sometimes have a restricting effect on the flow of water during peak rates if the heaters are designed so that the total cross-sectional area of the tubes is too small. Lack of understanding of this has led to unnecessary pipe replacement. It would be well if the manufacturers gave consideration to supplying heaters with a larger number of tubes in preference to depending on a smaller number of longer tubes for the same heat transfer surface.

When a building is equipped with an instantaneous heater the operation of the boiler during the summer months when the steam is off is controlled

by an aquastat that starts and stops the oil burner as required to maintain the temperature of the boiler water between 180 and 200 degrees F. Some operators are inclined to switch off the controls at night but this is not good practice. Heat should be maintained 24 hours daily to minimize temperature fluctuations. The level of the water in the boiler should be kept high enough so that tubes of the instantaneous heater are always submerged.

Circulation of the Hot Water Supply

Another important operating condition which merits close attention is circulation of the hot water. This means keeping the hot water circulating past the faucets or outlets at all times so that a prompt flow of hot water is provided at such outlets. Good circulation also avoids excess fluctuations of temperature which otherwise occurs when lukewarm water first appears at a faucet and then hot water finally starts running. As already stated, such fluctuations cause expansion and contraction strains at screwed joints and are a common contributory cause of leaks. Moreover, temperature fluctuations tend to dislodge rust formed in galvanized iron lines and this may have the effect of discoloring the water and causing stoppages in smaller diameter pipes. Leaks and clogging of lines is equivalent in cost to destruction by corrosion because the pipe no longer is serviceable and must be replaced.

Providing a prompt supply of water at outlets will avoid the waste of water and heat entailed by the tenants' running off large volumes of lukewarm or partly heated water while waiting for it to run hot. For example, if 100 tenants find it necessary to run off warm water at 100 degrees F for 5 minutes daily at a rate of 5 gpm, i.e., a total of 25 gallons per day each, the loss in heat units per months will be equivalent to 430 gallons of oil. At 12c per gallon this is equivalent to approximately \$50. Add to this the cost of the 75,000 gallons of water wasted per month at

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a cost of approximately \$15 and one arrives at a cost for water wastage plus heat units of \$65 monthly.

Figures 3 and 4 show in simplified diagrammatic form the hot water distribution systems most commonly used. Figure 3 (Direct Feed System) shows the water leaving the hot water generator and going to a horizontal distributor in the basement, off which are taken laterals that connect to up feed risers. Off these risers are taken the branch lines to the fixtures. Each riser has a circulation return line connecting to a return main in the basement and the circulation water is carried back to the hot water tank. This type of hot water piping system is the one most frequently used in the buildings of garden-type housing developments.

Figure 4 (Overhead System) shows diagrammatically the design of a piping system commonly used in tall buildings where all hot water piping is under roof tank pressure. There is a down feed supply line carrying cold water from the roof tank to the hot water generator in the basement. From the hot water generator an up feed hot water riser goes to a horizontal distributor in the roof and off this distributor are laterals connected to down feed risers, off which are taken the branch lines to the fixtures. The risers terminate in a circulation return system in the basement.

It is interesting to point out that the design of this type of distribution design was inspired by the desire to remove the dissolved oxygen which is released when the temperature is raised in the hot water generator. This oxygen was intended to be vented by the line taken off the top of the overhead. Actually, however, most of these air-vent lines become clogged and inoperative, thus failing to fulfill a sound theoretical concept. A common incidental trouble is the sputtering of air from fixtures because of the failure of the air venting. Disturbance of deposits and consequent discolored water is another manifestation. Moreover, it has been found that the overhead distribution line is the first to become corroded and require replacement. This is the most expensive pipe to replace because of its location, requiring opening of the roof, whereas in the older direct up feed systems the main distributor is easily accessible in the basement.

In the past it has been common practice to rely for circulation on the difference in density (resulting from different temperatures) between the water in the vertical supply risers and the water in the vertical return lines. In recent years, however, it has been recognized that positive circulation by means of pumps installed on the main returns, as shown in Figures 3 and 4, is desirable.

The principal causes of sluggish circulation are not necessarily due to corrosion. They are the resistances offered by:

1. Air pockets at high points in the system.
2. Sediment accumulations at low points.
3. Long horizontal runs of piping.
4. Inadequate size of return pipes.
5. Defective check valves.
6. Rust or hardness deposits in pipes.

Pockets are formed by the air which comes out of solution at points of low pressure in the piping system due to raising the temperature of the water in the hot water generator. Municipal supplies normally are saturated with air or oxygen at temperature and pressure conditions existing at the reservoirs, i.e., atmospheric pressure and temperature of the water. When the water reaches the city it is undersaturated due to the approximate two to six atmospheres (30 psi to 90 psi) delivery pressure. However, a rise in temperature due to heating will establish the basis for a supersaturated condition; thus, when the pressure drops at high points in the building, air will be released. Unless the piping is properly vented the air will accumulate at the high points in the system and will interfere with circulation. This trouble is avoided in the "direct feed" system by the air being vented through the topmost fixtures whenever water is drawn. To accomplish this, the circulation return riser is joined to the up-feed riser below the highest fixture. (See Figure 3.)

With the "overhead" system the horizontal distribution main on the top floor, if under street pressure, may be vented through the highest fixtures, or if the main is in the roof and above the highest fixtures it can be vented through a float-operated air trap installed on the roof. If the building is fed from a roof tank the hot water piping is vented by running a pipe from the highest point in the overhead main to a point above the level of water in the tank (see Figure 4), as has been mentioned.

All domestic water supplies contain a little sediment. The amount may not be noticeable to the consumer but it will accumulate gradually at low points in the system, such as the foot of the risers, in horizontal return lines where flow is relatively slow and in the bottoms of hot water storage tanks. In the first case the resultant interference with the circulation can be avoided largely by providing "heels" (tees and drain valves) at the foot of the risers and returns to allow for occasional flushing.

Check valves are installed on return lines to prevent "flow reversal" which would allow cold water to back up the returns and thus reduce the temperature of water at outlets. When reversal does take place, tenants usually complain that the hot water is "cold," or that its temperature fluctuates. This trouble generally is found to result from defective check valve operation, an insufficient number of check valves or to someone having removed the flaps from the checks in an attempt to increase the flow of water to the faucets by permitting flow from both the riser and the return. (See Figure 4.)

In many buildings only one check valve is used and it usually is located at the end of the circulation main in the basement. This check valve, if operating properly, will prevent cold water from backing up into the return lines but will not prevent water from one down feed riser backing up into another. Thus, in the case of the distribution systems described here it is possible for tenants, particularly those on the lower floors to be supplied from the bottoms of adjacent return risers if the supply from the overhead is restricted by deposits. This flow reversal, or

two way flow, may have the effect of maintaining the desired volume of flow at the faucets but it will cause complaints about low temperatures and probably about discolored water. To overcome these temperature complaints check valves should be installed on the return line from each riser.

It has been observed in many installations that the circulating pump installed is not of sufficient capacity to maintain sufficient circulation. In large buildings or building developments with long runs of horizontal pipe it is necessary to use a centrifugal pump of sufficient capacity to return the water at a temperature of not less than 100 degrees F. A pump should be installed with automatic controls so it starts when the temperature of the return water falls below 100 degrees F and stops when the temperature goes to 110 to 120 degrees.

A thermometer should be installed on the main hot water supply line so the superintendent or engineer can observe the temperature of the water at any time, otherwise some of the controls could be out of order without his knowledge. Sometimes it is necessary to balance the system by partly closing the valves on the return risers nearest to the pump because of the tendency for most of the return water to be pulled through nearby lines. If this happens there will be little, if any, circulation through risers and returns farthest from the pump.

In many garden-type apartment house developments of Federal Housing Administration construction, hot water for a number of buildings is supplied from a single hot water generator. The main hot water supply line from the generator branches off in two directions calling for two separate circulation return lines to the hot water generator. The usual arrangement is for the circulation return line to be joined so the water is handled by one circulation pump. It has been found with this arrangement that there may be a great difference between the return lines in the amount of water circulated and that reversal of flow direction may take place from one loop to the other with consequent discoloration of the water from disturbance of the accumulated sediment. To avoid these difficulties it is recommended that a check valve be installed on each return line rather than one check valve at the pump.

It has been observed also in many garden apartment developments that the circulation return lines are of 1/2-inch pipe. Even small amounts of sediment accumulated in small horizontal lines will greatly restrict their capacity. It is recommended that these lines be at least 3/4-inch if brass or copper and 1-inch if iron.

It is important to solve the operating problems causing poor hot water circulation because complaints by tenants regarding low or fluctuating temperatures usually lead the superintendent to raise the temperature of the entire supply in an effort to eliminate the complaints. In so doing he may aggravate the situation by starting another cycle of troubles due to excessively high temperatures. Again it is obvious that corrosion rates in the pipe are closely related to operating conditions.

Design and Fabrication of the Piping System

Reference already has been made to problems which reflect the original design of the water distribution system. Good design and fabrication can make for greatly improved services and longer life. Here are some suggestions:

1. Use gate valves instead of globe valves, because they offer less resistance to flow and they do not accumulate sediment as do globe valves.
2. Hot water storage tanks should be provided with full-size manholes to permit proper cleaning.
3. Dirt and sediment traps should be installed at the heels of all vertical lines in the form of clean-out tees with drain valves. Convenient flush-out points should also be provided for horizontal lines.
4. Supply branches from horizontal mains are best taken from the top half of the pipe. This avoids formation of sediment traps and pocketing of air.
5. Ground joint unions should not be used in galvanized jobs. Experience has shown that the brass seat has been the cause of abnormal localized corrosion within the union so that a restriction eventually develops.
6. Ample pipe sizes should be used to allow for the increasing frictional resistance caused by corrosion. This is particularly important in the case of the smaller pipes.
7. Every effort should be made to remove the burrs caused by pipe cutting, because they provide places for sediment to accumulate and may thus cause restrictions, or bottlenecks and reduce the flow of water. Corrosion usually gets the blame.
8. The use of bushings, street ells and reducing fittings should be minimized because they, too, cause bottlenecks by providing a shoulder for the build-up of deposits which reduce water flow. Corrosion usually gets the blame.
9. Pipe compound should be spread on the pipe threads only and not on the thread of the fitting. If the latter is done, compound is frequently pushed into the fitting where it solidifies and forms a bottleneck to reduce the water flow. Corrosion usually gets the blame.
10. At places where iron and brass are joined because of the use of brass fixtures, some easily replaceable iron nipples should be provided at the junction of the two metals to absorb the effect of the galvanic current created.
11. Instantaneous or tankless heaters should be provided with the necessary connections for "backwashing" them to remove sediment that otherwise tends to accumulate. Dirty coils mean reduced volume of hot water—another temptation to compensate by raising temperatures.

Corrosion of Different Kinds of Pipe

One effect of corrosion on galvanized steel and galvanized wrought iron pipes is to build up in them

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a deposit of iron oxides that will so restrict the flow of water that the useful life of the pipe is ended before it may be penetrated by the pitting action of the water.³ It has been estimated that it may take only 1/40th of the thickness of the pipe wall converted into rust to completely clog an iron pipe. The rate and type of corrosion in galvanized pipe depends principally on the following factors:

1. The corrosiveness of the water.
2. The temperature of the water.
3. The quality of the galvanizing.
4. Operating conditions.

In yellow brass pipe corrosion takes the form of dezincification and may be localized in the so-called plug type of dezincification or it may be more or less uniform over the entire pipe surface. When the plugs penetrate the pipe wall, leaks result. Also, when dezincification occurs at the base of the threads where the metal is thinnest, there is likelihood of the pipe breaking, especially if it is subjected to the strains of expansion and contraction.

The effect of corrosive water on copper tubing is to penetrate the metal with small pinhole perforations, particularly at higher critical temperatures.

Red brass pipe is resistant to the action of most waters, but not all. It may become so pitted and damaged that it has to be replaced. Both red brass pipe and copper tubing may impart a blue-green color to corrosive waters even though the action of the water on the metal would be comparatively small.

Treatment of the Water

In many municipalities it is a practice to apply corrective treatment to the entire water supply to diminish its corrosiveness. The treatment most usually employed is to add lime to the water because that is the cheapest material to use when very large quantities of water are involved. The usual practice is to feed sufficient lime so that the water is in equilibrium with calcium carbonate.

Lime cannot be used readily in the treatment of the water supply in individual buildings because of the difficulty of feeding the lime, so individual consumers have recourse to other treatments such as sodium silicate⁷ with or without other alkaline substances as called for by the composition of the particular water.

A number of years ago an attempt was made in several buildings in New York City to protect the piping by passing the water through a "deactivator"⁶ which consisted essentially of a tank containing scrap iron which removed the oxygen from the water. The procedure never was very successful because of operating difficulties that arose, including the necessity for filtering the rust and color from the water after it left the deactivator.

The supplementary treatment of water in building piping systems is not new. Water Service Laboratories have been doing it in a number of eastern

cities for over 25 years. Sodium silicate has been the basis of the treatment.⁷ Two large municipalities have taken the lead in recognizing the value and necessity of such supplementary treatment and have enacted controlling codes and ordinances. New York City did it in 1939⁸ and Detroit in 1943.⁹

Other Uses of Water in Buildings

Modern construction incorporating the use of circulating water systems such as radiant heating systems, hot water heating systems and the cooling water for large air conditioning systems has posed further corrosion problems which again are intimately related to operating conditions. For example, there seems to be a difference of opinion as to the advisability of treating water in radiant and other hot water heating systems for the purpose of preventing corrosion or scale formation. Water Service Laboratories believes that treatment is called for.¹¹

Theoretically, such systems do not need water treatment because it might be supposed that there is no makeup required, i.e., the same water stays in them all the time and once its corrosive effect has been expended no further corrosion takes place. As a matter of fact, however, it has been found generally that for several reasons there is a turnover of water which requires feeding into the system the dissolved corrosive gases and scale-forming salts present in the makeup.

Expansion tanks frequently become water-logged because of failure to replenish the air pocket so that at each rise in temperature water may be discharged through the relief valves and when the temperature drops new water must enter the system.

The expansion tank is normally on the discharge side of the pump. The pump suction connection is at a lower pressure which at times may fall below atmospheric pressure and this can result in drawing air into the system. Automatic air vents may discharge air present above saturation but they cannot remove dissolved air.

Another cause of turnover is loss of water at the packing glands of certain types of pumps, leaking safety valves and radiator bleeds. Even if there is no loss of water from the system, oxygen may be absorbed by the water in the pressure tanks and this will increase its corrosiveness.

Chemical treatment of the water in the system and the periodic analyses of the water to determine if the treatment is sufficient will disclose very quickly if there are any leaks. Without such tests a leak might go undetected for a long time during which extensive corrosion could take place as well as waste of fuel due to the loss of the heated water. The corrosion also might cause clogging of the smaller pipes.

In cooling towers, evaporative condensers and air washers in air conditioning systems, the corrosiveness developed by non-scaling waters is due to the constant scrubbing from the atmosphere of such gases as oxygen, carbon dioxide and sulfur dioxide. pH values as low as 3.5 to 4¹⁰ have developed, re-

quiring the corrective application of alkali and chromates for most effective corrosion prevention. Two of the operating conditions which require special attention in designing this type of anti-corrosion treatment are local atmospheric conditions and the nature and variation of the air conditioning load.

These latter piping systems in buildings have been mentioned briefly because so much piping is involved. They merit a further discussion that could not be included in a paper of this length.

It will be obvious, however, from the few examples given here that operating conditions exert a major influence on corrosion and that design of piping systems based on theoretical considerations cannot be depended upon to prevent corrosion troubles unless backed up by good fabrication and sound maintenance and operating procedures.

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Measured Potentials as Related to Corrosion And Polarization in Local Cells *

By THOMAS P. MAY* and F. L. LaQUE*

THE ELECTROMOTIVE force series of metals listing their reversible potentials when exposed to solutions of their respective ions at unit activity is well known. The values in this series reflect the magnitudes of the free energy changes that would result if the metals should corrode under the standard conditions. They also indicate the probable conditions of equilibrium in accordance with the equilibrium constant for the particular reaction. This series refers only to potentials of pure metals undergoing changes from the metallic state to a specific ionic state. It is also well known that these reversible potentials of metals in their standard states are not reliable guides to their likely corrosion rates in any given environment.

In the more common exposures of metals, quite different potentials are frequently exhibited as illustrated in Table 1 by aluminum when immersed in flowing sea water. On the basis of the standard potentials, one would expect aluminum to suffer severe galvanic corrosion if it were coupled to zinc in a solution. The reverse galvanic action usually occurs because aluminum rapidly develops a passive condition and in sea water actually becomes 200 millivolts more noble than zinc.

Furthermore, these corrosion potentials do not reflect the resistance to or lack of resistance to corrosion. For example, LaQue¹ published the potentials and corrosion rates of several materials in sea water as listed in Table 2. The materials are listed there in the order of increasing nobility as one goes down the list. The corrosion rates do not similarly fall into an order of decreasing values. This behavior of metals and alloys has been explained in terms of the reactions occurring at the local anodes and cathodes on the exposed surfaces. For example, Mears and Brown² graphically illustrated the potentials of local elements in the surface and the polarization that occurs on the same elements as a result of the corrosion currents that flow between them. Using plots of local element potential versus local cell current, they illustrated how several metals may suffer the same corrosion rate but exhibit different corrosion potentials, the latter being largely controlled by the open circuit potentials of the local anodes and cathodes and the relative degrees of anodic and cathodic polarization resulting from the corrosion current. LaQue¹ illustrated this further by visualizing two metals that suffer corrosion rates of different magnitudes at the same potential. In this instance the similar potentials

Abstract

Following a brief review of the theory of reversible electrode potentials, irreversible electrode potentials of corroding metals are discussed with particular reference to corrosion rates. Experiments in sea water provide evidence that neither reversible nor irreversible potentials can be used to estimate corrosion rates. The Mears and Brown concept of local cell action explains this lack of co-ordination. Polarization properties similarly account for the observed galvanic corrosion when dissimilar metals and alloys are coupled. Anodic and cathodic currents from an external source were applied in separate experiments to steel in flowing sea water. Potentials measured at several current densities permitted the construction of anodic and cathodic polarization curves. These potentials and corresponding corrosion rates permitted the construction of approximate polarization curves for the local anodes and cathodes on steel in flowing sea water.

were developed from local anodes and cathodes with sharply different polarizing characteristics.

LaQue¹ also considered the analogous situation in the galvanic corrosion that occurs when dissimilar metals are coupled together in an electrolyte. Using couples of steel and several more noble metals in flowing sea water, he demonstrated that the galvanic effects were

- dependent upon the cathode material and
- not proportional to the open circuit potential differences between steel and the various cathode materials.

A consideration of the cathodic polarization of these metals showed that the lack of proportionality between the galvanic corrosion and the cell potentials was associated with the polarization characteristics of the cathode materials. Those that were more readily polarized caused the lesser galvanic corrosion.

TABLE 1
Electrode Potentials of Several Metals Corroding in Sea Water and Their Reversible Potentials in the Standard State

Metal	Potentials, volts vs. sat. calomel	
	Reversible	Corrosion
Aluminum	1.946	0.78
Zinc	1.008	1.03
Iron	0.687	0.60

TABLE 2
Open Circuit Potentials and Corrosion Rates of Metals in Sea Water Flowing at 13 fps at 25° C.

Metal	Steady Potential* Corrosion Rate	
	volts	mdd
Zinc	1.03	1490
Aluminum 3S-H	0.79	45
Carbon Steel	0.61	325
Naval Rolled Brass	0.40	24
Copper	0.36	106
Type 410 (13% Cr) S. S.	0.15	114
Hastelloy C	0.08	2

* Values are negative vs. saturated calomel reference half cell.

* A paper presented at the Ninth Annual Conference, National Association of Corrosion Engineers, Chicago, Ill., March 16-20, 1953.

* Corrosion Engineering Section, Development and Research Department, International Nickel Co., Inc., New York, N. Y.

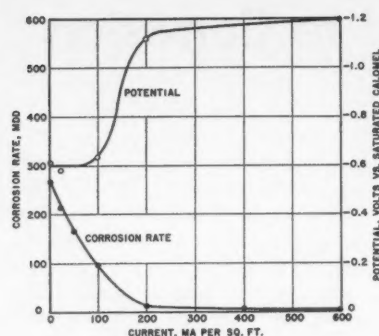


Figure 1—Cathodic polarization of low carbon steel in sea water moving at 7.8 fps. Area of cathode = 2.875 sq. in.

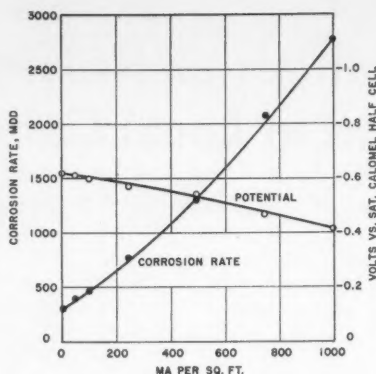


Figure 2—Anodic polarization of low carbon steel in sea water at 7.8 fps. Area = 2.875 sq. in. Duration = 11 days.

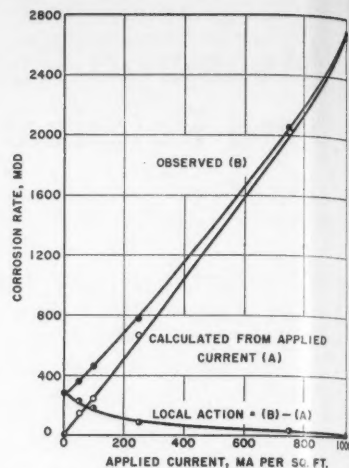


Figure 3—Effect of anodic current on local cell action when applied to steel in sea water moving at 7.8 fps, 10-14 degrees C.

In view of the importance of the effects of current on the behavior of local elements in a metal surface, considerable attention could well be directed toward methods by which such characteristics might be determined and studied. One method was proposed by Mears and Brown³ in which they used the anodic and cathodic polarization curves that might be readily established for a metal by the direct application of external anodic and cathodic currents and the weight losses corresponding to these applied currents. In using this method, it was assumed that the potential of a metal surface, as measured with a suitable reference electrode, was approximately that of the polarized local anodes and cathodes. Proceeding from this assumption, the application of an external cathodic current resulted in a more intensive polarization of the local cathodes which in turn reduced the local cell current until a point was reached where the local cathodes were actually polarized to the open circuit potential of the local anodes. Corrosion by local cell action was zero at this stage. Accordingly, one can estimate the open circuit potential of the local anodes determining the potential at which corrosion is reduced to zero by the application of a cathodic current. Similarly the application of an external anodic current will result in an increase of current flowing from the local anodes. When this current is sufficiently increased, the anodes can become polarized to the open circuit potential of the local cathodes. Local cell action is then zero and all corrosion is due to the applied anodic current. By plotting (as in Figure 3) the corrosion equivalent (A) of the applied current and the observed corrosion (B) against applied current, one may determine the applied current at which the two curves merge into one. The potential at this applied current density is the open circuit potential of the cathodes.

By consideration of the net currents on the anode and cathode areas, polarization curves may be constructed for the local anodes and cathodes. The observed corrosion rate is always equivalent to the local anode current. The observed potential of the corroding metal is always approximately equal to the polarized potentials of the local anodes and local cathodes, as already stated. Furthermore, applica-

tion of an external cathodic current reduces the corrosion rate and hence, the local anode current. It also tends to increase the polarization of the local cathodes and decrease the polarization of the local anodes, leading to a shift in the observed potential. As the applied cathodic current is increased, the local anode current eventually drops to zero; at the same time, the observed potential approaches the open circuit potential of the local anodes. Therefore, a plot of the observed potentials versus these local anode current densities that are derived from corrosion rates at the several applied cathodic current densities provides an approximation of the local anode polarization characteristics. Similarly upon applying an external anodic current, the difference between the observed corrosion and the corrosion equivalent of the applied current (B)-(A) is assumed to equal the local action corrosion. The current equivalent of this local action corrosion is equal to the local cathode current. Hence, a plot of observed potential, which is approximately equal to the polarized potential of the local anodes, versus this calculated cathode current provides an estimate of the local cathode polarization curve. To determine the exact shape of these local cell polarization curves would require knowledge of the actual anode and cathode area relationships.

Experimental Estimation of the Local Cell Polarization of Steel in Flowing Sea Water

Some observations on the anodic and cathodic polarization of steel in sea water provide an opportunity for applying this method. Furthermore, this treatment gives some opportunity for speculation on the mechanism by which cathodic protection of steel in sea water is achieved.

Specimens of freshly abraded low carbon steel were exposed to sea water flowing at 7.8 feet per second. Constant currents were applied for a period

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of four days to a series of identical specimens, each one at a different current density. During this period potentials were measured at regular intervals with a saturated calomel half cell fitted with a tubulus, the tip of which could be placed near the steel surface each time a potential measurement was to be made. At the end of a run, the specimens were cleaned and their weight losses determined.

The cathodic polarization data in Figure 1 show a considerable decrease in corrosion as the cathodic current increased to about 200 ma per sq. ft. Further increases in applied cathodic current effected a further slight reduction in corrosion but did not bring it to zero. A very substantial decrease in corrosion was achieved without any appreciable change in the observed potential. This shifted rather abruptly in the anodic direction when most of the corrosion had been eliminated by the application of more current.

Application of an external anodic current yielded the data in Figure 2. Weight loss increased with increasing applied current while potential shifted in the cathodic direction. Figure 3 presents the observed weight losses and corrosion equivalent of the applied current plotted against the applied current. The potentials from Figure 2 were then plotted in Figure 4 against the current equivalent of the differences between the curves A and B in Figure 3. Each of these differences actually represented the corrosion rates which resulted from the flow of the local action currents. The plot, therefore, represents the local action cathodic polarization curve on the left in Figure 4. The local anodic polarization curve also on the left in this same figure was constructed with the cathodic polarization data from Figure 1 as previously described. It should be noted that these local element polarization curves have been constructed without regard for the areas involved. If the areas remain constant in size as the applied current increases, their shapes would be as shown. On the other hand, the curvature would be altered by any variation in area of anodes and cathodes as the local current intensity increases.

Discussion of Estimated Polarization Curves

It would appear from this treatment that the unpolarized local cathode potential on low carbon steel in flowing sea water is about -0.42 volt referred to the saturated calomel electrode. The unpolarized anode potential appears to be approximately -0.76 volt on the same scale. This latter value is in good agreement with the value, -0.77 volt, at which Schwerdtfeger and McDorman⁴ reported iron to be in equilibrium with ferrous hydroxide and free from corrosion in soils.

It should be noted that a very sharp change in potential to approximately -1.2 volt occurred before the local cell action approached zero. This sharp change indicates a change in the cathode reaction from the one occurring in the nor-

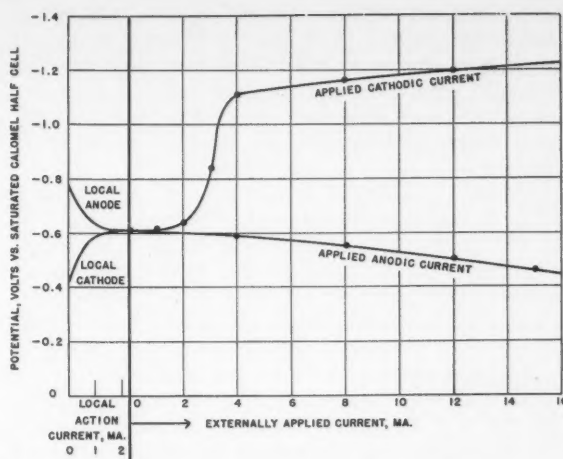


Figure 4—Approximation of local action polarization from anodic and cathodic polarization data obtained with steel in sea water moving at 7.8 fps. Area of steel specimen = 2.875 sq. in.

mal corrosion reaction and the one associated with the higher current densities from the external source. The value of -0.76 volt was, therefore, obtained by

- extrapolating the corrosion rate curve in Figure 1 to zero on the basis of the rates observed from 0 to 50 ma per sq. ft. of applied current and using the value of potential on the same graph that corresponded to this applied current at "zero corrosion," and
- by extrapolating the local anode polarization curve in Figure 4 to zero current and ignoring the sharp shift in the potential caused by the incidence of the new cathode reaction.

These values for the unpolarized potentials of the local anodes and cathodes have been estimated without regard to the current densities on the local elements and may be considered reliable if one accepts the theory that local cell corrosion is reduced to zero when the externally applied current reaches a sufficient magnitude. On the other hand, the local element polarization curves as presented were estimated on the basis of unchanging areas of local anodes and cathodes. Accordingly, their precise

TABLE 3
Relationship between Applied and Local Action Currents
in the Cathodic Polarization of Steel in Sea Water Flowing at 7.8 FPS

Applied Current Density, ma/sq. ft. of Specimen	Observed Corrosion Rate, mdd	Current Equivalent of Corrosion Rate ma/sq. ft. of Specimen	Net Current Density On Local Anodes and Cathodes ¹		Observed Potential, Volt Relative to Saturated Calomel Half Cell
			Anodic	Cathodic	
0	288	107	214	214	0.617
5	258	96	192	202	.617
25	216	80	160	210	.680
50	160	59	118	218	.620
100	96	36	72	272	.630
200	10	3.7	7.4	408	1.120
400	4	1.5	3.0	804	1.120
600	3	1.1	2.2	1202	1.200

¹ Net current densities ma per sq. ft. of anode area and of cathode area, based on the assumptions:

- That the local action anodic and cathodic areas are equal and represent in each case 50% of the total area of the specimen.
- That up to the point of cathodic protection all the applied current flows to the cathodic areas.

shape is not necessarily indicated by the local action polarization curves in Figure 4 because it is not known how the areas may shift with time or with externally applied currents. An exact means for identifying these areas and their extent is necessary before the polarization curves may be defined more precisely.

A further consideration of the local cell currents during the application of cathodic current from an external source is of considerable interest, especially with respect to the basis for the Mears and Brown treatment just applied to steel. One may assume for purposes of illustration that the local action anodic and cathodic areas on steel in sea water are equal in size representing in each case 50 percent of the total exposed area and that all of the applied current flows to cathode areas. Under such conditions the net current densities on the local anodes and cathodes will be distributed as shown in Table 3. With no applied external current the net current densities on the local anodes and cathodes will be equal and just double the current equivalent of the corrosion rate based on the total surface area. When an external cathodic current is applied, e.g., 5 ma per sq. ft. of total surface area, the net local anode current density is still equal to twice the current equivalent of the corrosion rate based upon the total surface area. In this case it is 192 ma per sq. ft. of local anode area. The net local cathode current density is now equal to the local anode current density plus the applied external current density ($192 + 2 \times 5 = 202$ ma per sq. ft. of local cathode area). On this basis, it would appear that the net current density on the local cathode areas does not change appreciably until virtually all of the local anode current is eliminated. In this same region, below 200 ma per sq. ft. of applied current, the observed potential of the steel remains virtually unchanged. Further increases in the applied external current lead to marked increases in local cathode current density and a similar abrupt change in the observed potential.

This pattern of current distribution over the local anode and cathode areas accounts reasonably well for the flat portion of the cathodic polarization curve of steel and strongly suggests that the major role of an external anode in a cathodic protection system is

to increase the effective anode area (local plus external). This mechanism in effect redistributes the source of current flowing to the local cathodes and results in a lower local anode current density.

On the other hand, it is not likely that the local anodes become inert areas when their current densities are reduced to zero. On the contrary they are probably converted into cathode areas and the current on them is reversed. When this has occurred, net current densities on the local cathode areas would be reduced in proportion to the conversion of local anodes to new local cathodes.

Once anodic reactions have been eliminated and the whole surface has become cathodic, the potentials that will be observed as the result of the continued application of current will be determined by whatever cathodic reaction is occurring. In the practical application of cathodic protection, there will be reactions that proceed at potentials higher than those of the original anodes, for example, over 0.76 volts vs saturated calomel. Under some circumstances the cathodic reaction, for example on steel in sea water, may be principally oxygen reduction and, as in the case of the cathodic areas on a normally corroding steel surface, the potential associated with absence of corrosion will be that of the cathode rather than one approaching that of the anode. Such a transient condition as to observed potential might be realized on a steel specimen in sea water just when all the anodic areas had been eliminated and before any change in the cathodic reaction, for example, hydrogen evolution, could occur as a result of further additions of current sufficient to increase the over-all cathodic current density.

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Sea Water Immersion Trials Of Protective Coatings*

By J. H. GREENBLATT

Introduction

IN EARLIER investigations into the corrosion of underwater hulls of ships Barnard^{1,2} showed by closeup potential surveys of the underwater hull, that the protective life of underwater paint films then used on Canadian Navy Ships was short and that even if it were extended, paint by itself could not completely protect the hull against corrosion. Supplementary protection was needed and, as a result, Barnard initiated trials to determine if cathodic protection could be applied to ships and protect them completely.

The effect of these findings was that a paint testing program was also initiated at the Naval Research Establishment with the object of investigating the behavior of underwater finishes and in particular, of determining how such coatings behaved under the influence of the protecting cathodic current. Because the Naval Research Establishment had, and still has, no facilities for formulating and mixing paints, commercial firms were contacted for samples of their regular underwater finishes and any experimental type of paint they cared to supply. The trials were carried out over the last five years with both panel and shipboard tests of promising formulations included.

During this period the successful implementation^{3,4} of cathodic protection as a method for preventing corrosion on ships' underwater hulls emphasized new requirements for paints used in conjunction with this technique. These are:

Firstly, the paint used should not be stripped off or blistered by the protecting current.

Secondly, the antifouling paints used on a cathodically protected bottom should have a toxic life sufficiently long so that the savings on maintenance costs accruing from the use of cathodic protection will not be negated by the need to drydock for cleaning off fouling and renewing antifouling paint. At present, a two-year antifouling life has been set as the goal.

Experimental

a. Panel Tests. The panels used were one foot square with a question mark-shaped hook welded to one edge to serve as a support and a point of attachment for electrical leads. The panels were No. 10 gauge rimmed steel in the majority of cases. In the later part of the work similar aluminum panels were also exposed. All paint applied to steel, whether panels or ship's plating, was applied to sandblasted steel. The panels were prepared for painting by degreasing, with trichlorethylene and treating with 2 percent cold phosphoric acid, while the steel on ships

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Abstract

Sea water immersion trials of a variety of types of underwater compositions have shown the superior performance of vinyl finishes, both as protective and antifouling paints. Panel tests have shown that vinyl finishes can be used on cathodically protected hulls and shipboard trials have substantiated this, provided that a controlled cathodic protection system is used.

was treated with acid only. Before painting, excess phosphate salts were wiped off the steel. No attempt was made to control or measure the sandblast pattern and the profile height of the sandblasted steel was probably greater on ships' surfaces than on the test panels. The paint was applied so as to get good thickness without runs or sags and the panel edges were sealed with paraffin wax.

In all panel tests, duplicate sets were immersed. One set was maintained cathodically at 860 millivolts with respect to a silver-silver chloride electrode while the other set was not subjected to any applied voltages. The value of the set voltage was arbitrarily chosen to simulate an upper limit to which an actual cathodically protected ship would be polarized.

It has been shown by many workers^{1,5} that protection of steel in sea water occurs at 760 millivolts but on non-planar surfaces, re-entrant angles, crevices, etc. will not be protected when the whole surface containing them is polarized to 760 mv, and ships' hulls in sea water are polarized to slightly higher values to ensure adequate current throw to these regions. Also, as some depolarization occurs when active cathodically protected ships get underway, this effect also must be compensated for. Thus, it has become the practice to maintain Royal Canadian Navy cathodically protected active ships at a potential of 820 to 840 millivolts and the 860 millivolts chosen for the test would be an imposed arbitrary limit which fluctuations might reach or even exceed,

*Submitted for publication June 1, 1953.

shape is not necessarily indicated by the local action polarization curves in Figure 4 because it is not known how the areas may shift with time or with externally applied currents. An exact means for identifying these areas and their extent is necessary before the polarization curves may be defined more precisely.

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to increase the effective anode area (local plus external). This mechanism in effect redistributes the source of current flowing to the local cathodes and results in a lower local anode current density.

On the other hand, it is not likely that the local anodes become inert areas when their current densities are reduced to zero. On the contrary they are probably converted into cathode areas and the current on them is reversed. When this has occurred, net current densities on the local cathode areas would be reduced in proportion to the conversion of local anodes to new local cathodes.

Once anodic reactions have been eliminated and the whole surface has become cathodic, the potentials that will be observed as the result of the continued application of current will be determined by whatever cathodic reaction is occurring. In the practical application of cathodic protection, there will be reactions that proceed at potentials higher than those of the original anodes, for example, over 0.76 volts vs saturated calomel. Under some circumstances the cathodic reaction, for example on steel in sea water, may be principally oxygen reduction and, as in the case of the cathodic areas on a normally corroding steel surface, the potential associated with absence of corrosion will be that of the cathode rather than one approaching that of the anode. Such a transient condition as to observed potential might be realized on a steel specimen in sea water just when all the anodic areas had been eliminated and before any change in the cathodic reaction, for example, hydrogen evolution, could occur as a result of further additions of current sufficient to increase the over-all cathodic current density.

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Sea Water Immersion Trials Of Protective Coatings*

By J. H. GREENBLATT

Introduction

IN EARLIER investigations into the corrosion of underwater hulls of ships Barnard^{1,2} showed by closeup potential surveys of the underwater hull, that the protective life of underwater paint films then used on Canadian Navy Ships was short and that even if it were extended, paint by itself could not completely protect the hull against corrosion. Supplementary protection was needed and, as a result, Barnard initiated trials to determine if cathodic protection could be applied to ships and protect them completely.

The effect of these findings was that a paint testing program was also initiated at the Naval Research Establishment with the object of investigating the behavior of underwater finishes and in particular, of determining how such coatings behaved under the influence of the protecting cathodic current. Because the Naval Research Establishment had, and still has, no facilities for formulating and mixing paints, commercial firms were contacted for samples of their regular underwater finishes and any experimental type of paint they cared to supply. The trials were carried out over the last five years with both panel and shipboard tests of promising formulations included.

During this period the successful implementation^{3,4} of cathodic protection as a method for preventing corrosion on ships' underwater hulls emphasized new requirements for paints used in conjunction with this technique. These are:

Firstly, the paint used should not be stripped off or blistered by the protecting current.

Secondly, the antifouling paints used on a cathodically protected bottom should have a toxic life sufficiently long so that the savings on maintenance costs accruing from the use of cathodic protection will not be negated by the need to drydock for cleaning off fouling and renewing antifouling paint. At present, a two-year antifouling life has been set as the goal.

Experimental

a. Panel Tests. The panels used were one foot square with a question mark-shaped hook welded to one edge to serve as a support and a point of attachment for electrical leads. The panels were No. 10 gauge rimmed steel in the majority of cases. In the later part of the work similar aluminum panels were also exposed. All paint applied to steel, whether panels or ship's plating, was applied to sandblasted steel. The panels were prepared for painting by degreasing, with trichlorethylene and treating with 2 percent cold phosphoric acid, while the steel on ships

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Abstract

Sea water immersion trials of a variety of types of underwater compositions have shown the superior performance of vinyl finishes, both as protective and antifouling paints. Panel tests have shown that vinyl finishes can be used on cathodically protected hulls and shipboard trials have substantiated this, provided that a controlled cathodic protection system is used.

was treated with acid only. Before painting, excess phosphate salts were wiped off the steel. No attempt was made to control or measure the sandblast pattern and the profile height of the sandblasted steel was probably greater on ships' surfaces than on the test panels. The paint was applied so as to get good thickness without runs or sags and the panel edges were sealed with paraffin wax.

In all panel tests, duplicate sets were immersed. One set was maintained cathodically at 860 millivolts with respect to a silver-silver chloride electrode while the other set was not subjected to any applied voltages. The value of the set voltage was arbitrarily chosen to simulate an upper limit to which an actual cathodically protected ship would be polarized.

It has been shown by many workers^{1,5} that protection of steel in sea water occurs at 760 millivolts but on non-planar surfaces, re-entrant angles, crevices, etc. will not be protected when the whole surface containing them is polarized to 760 mv, and ships' hulls in sea water are polarized to slightly higher values to ensure adequate current throw to these regions. Also, as some depolarization occurs when active cathodically protected ships get underway, this effect also must be compensated for. Thus, it has become the practice to maintain Royal Canadian Navy cathodically protected active ships at a potential of 820 to 840 millivolts and the 860 millivolts chosen for the test would be an imposed arbitrary limit which fluctuations might reach or even exceed,

*Submitted for publication June 1, 1953.

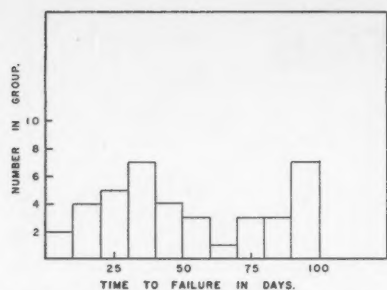


Figure 1—Summary of results in the ordinary immersion test.

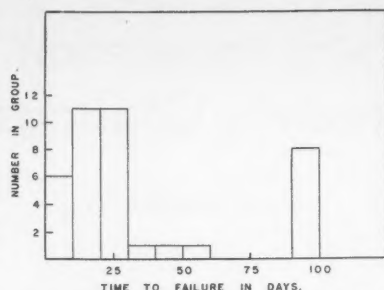


Figure 2—Summary of results in the simulated cathodic protection test.

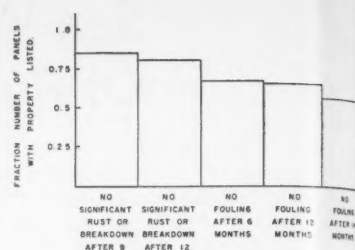


Figure 3—Summary of results from the long term test.

but which would be above the general average. Since preliminary trials had indicated the now well established fact reported by Crosby,⁶ Devoluy,⁷ Eickoff,⁸ Kulman,⁹ Shepard and Graeser¹⁰ and Sudrabin¹¹ that uncontrolled cathodic protection severely damaged the paint coatings in a short time, the potential was regulated at 860 ± 20 millivolts by an automatic regulator in the first two sets of trials and manually in later trials.

The silver-silver chloride reference electrodes, used throughout all this work, were constructed by dipping a tight roll of silver gauze, silver soldered to a silver supporting wire, in molten silver chloride. After coating, the electrode was subjected to a number of long low-current alternate reducing and oxidizing cycles to get reduced silver and silver chloride in intimate contact throughout the structure. The electrode was then attached to an insulated lead wire and mounted in an insulating protective case in such a way that the lower portion of the electrode had access to sea water, but the joint between electrode and lead wire was insulated by a sealing compound.

The condition of the paint films on the panels was assessed from measurements of the electrical resistance and capacity at 1000 cycles and the potential with respect to a silver-silver chloride electrode. The method of assessing continuity of a paint film by measurement of electrical properties has been developed by Young,^{12,13,14} Bacon,¹⁵ and Wormwell and Brasher.^{16,17,18} The last two authors have investigated the method thoroughly and have shown just what characteristics of the electrical properties versus time graphs indicate the onset of serious damage to the paint film and corrosion of the underlying metal. The panels were also checked periodically by visual inspection and assessed for freedom and fouling at these times.

Results

The first set of tests included eleven proprietary brands of paint, including vinyls, coal tar base, oil base, United States Navy Cold Plastic and a British equivalent to cold plastic. This test ran for ninety days. The paints could be separated into groups that failed at different times during the 90-day test period and one group that included all paints that survived the test without failure. Impressed voltage in the simulated cathodic protection test increased the distinction between this latter group and those groups

that failed within 90 days by decreasing the life of the worse paints. The better group consisted of vinyls, U. S. Cold Plastic and the British equivalent to cold plastic. The results are shown in Figures 1 and 2.

These initial trials were conducted during the summer months when fouling activity at Halifax is greatest. Most panels remained completely clear of fouling during the test period, but some did show light fouling at the end of the test. These panels were in the group with poorer protective properties. There was no indication that fouling was worse on the cathodically protected panels.

Subsequent testing involved similar immersion tests with the compositions that had shown good performance in the initial trials. Three series of panels were exposed over the two years, 1950-52 and the general result of these tests are discussed below. The exposures all were begun in the early part of the year so that the antifouling paints would have spent four to six months in the water before the season for heavy settlement at Halifax.

The first of these series consisted of seven sets of vinyl coated panels, two sets of chlorinated rubber coated panels and three sets of panels coated with oil base paints over a vinyl wash primer. The panels were exposed for 15 months and inspected periodically during this period. The results of this test are shown in generalized form in Figure 3. With reference to Figure 3, damage, such as very small blisters or small pin points of rust detectable by visual observation but not showing any effect as determined by plots of the resistance, capacity or potential of the panel against time, was not classed as significant damage. The vinyls gave good performance regardless of brand and the oil base paint over a vinyl wash primer also gave good results. One set of chlorinated rubber paints did poorly, the other well.

These panels had been through two summer fouling seasons and the vinyls as a class showed better performance than the non-vinyls. Up until 13 months' exposure all vinyls were free of fouling and some remained clear of fouling after 15 months' exposure. No chlorinated rubber antifouling paints were tested and the panels coated with chlorinated rubber paint had primer and anticorrosive coats only. Again the condition of cathodically protected panels as regards fouling was the same as the panels not cathodically protected.

The above results were confirmed by the behavior of the second series of panels immersed. These consisted of vinyls, chlorinated rubber systems, the British equivalent to cold plastic and a bitumastic paint. The vinyls as a class gave good results, 86 percent showing no significant damage after 10, 14 and 18 months of exposure. After 24 months' exposure, however, the vinyl panels showed some blistering. The chlorinated rubber systems tested in this trial had an antifouling coat and they showed poorer performance than those tested in the previous trial. Seventy-five percent of the chlorinated rubber panels showed blistering within four months after immersion followed by stripping of the top coat. The bitumastic coating showed good performance, but under cathodic protection, the coating became brittle and after 23 months was easily flaked off the panel. The British equivalent to cold plastic showed no damage or breakdown in the ordinary immersion test, but did show paint stripping in the simulated cathodic protection test.

The antifouling performance of the vinyl coated panels in this series was not as good as in the previous one. All panels were lightly fouled the first summer they were exposed, and after 24 months' exposure, the light fouling was still present but the fouling had not shown any increase. The vinyl panels in this series were all coated with paint of the same brand and batch number. With the chlorinated rubber panels some were fouled and others were not after 24 and 19 months' exposure. Again no difference was observed between the antifouling behavior of paints on the cathodically protected panels and on the unprotected ones except for the British cold plastic type paint. The difference was due to stripping of the outer antifouling paint coat by the protective current.

The third series of panels exposed are still immersed. The series consisted of steel and aluminum panels coated with vinyl systems of four different manufacturers. After one year's exposure, including one summer fouling season, all steel panels were in good condition and free of fouling. A few aluminum panels were corroding at corners where the paint and paraffin sealing had been damaged, exposing bare metal but all the aluminum panels were free of fouling. The panels all had been immersed four to six months before the start of the heavy fouling season and no difference in behavior of the antifouling paint between the cathodically protected and the unprotected panels was observed.

The paints supplied for all tests were mainly standard formulations. Non-vinyl primers were pigmented with iron oxide and all vinyl intermediate primers, except one batch containing iron oxide, contained red lead. The vinyl wash primer contained zinc chromate pigment. As a consequence of the above, the effect of pigment type size, etc., could not be observed in a systematic way. In the case of the vinyl formulations, no noticeable difference in behavior was observed between the red lead and iron oxide pigmented paints in the time the test was run.

The film thickness for the paints tested in the first two trials averaged between 2.5-3.5 mils, as meas-



Figure 4—Vinyl patch on a 1000-ton active sea going ship showing the superiority of vinyl and anti-fouling paints over ordinary commercial anti-fouling paints.

ured by a Magne gauge, while in the later trials film thicknesses, measured by a General Electric thickness gauge, were between 5 and 7 mils. The effect of vehicle type completely blanked out the effect of film thickness over all types tested, but within the non-vinyl or chlorinated rubber group, the thicker films showed up better.

b. Ship Tests. As the trials progressed, the results indicated that vinyl paints could maintain themselves on the plating of cathodically protected ships and as a paint with such properties was required to shield hull areas adjacent to magnesium anode systems so that better current distribution could be obtained on protected ships,⁴ it was decided to initiate large scale trials of vinyls on ship hulls which would run concurrently with the panel tests. In the first ship trials, vinyl was applied to the hull, treated as previously described, as a patch ten feet wide centering on the anode array. The superior behavior of vinyls over the previously used proprietary brands of paint was shown by a decrease in total anode current necessary to maintain the ship with a vinyl patch at the same protected potential as a similar ship without the patch. This result led to the specification of such a vinyl band around the anodes of all cathodically protected ships.

Inspection of the vinyl patches after periods of 12 to 15 months, immersion have shown, in cases observed to date, that the vinyl was free of fouling and with one exception was in good condition, except immediately adjacent to the anodes where some stripping occurred. On one ship, stripping of the vinyl in one foot diameter patches occurred over 20 percent of the vinyl patch. However, this ship was painted in winter in a graving dock under conditions of high humidity and temperatures between 40 and 45 degrees F, an environment that is not the best for application of vinyls.

In all cases where the antifouling paint was in good condition, the vinyl patches were free of fouling. An example of such a typical vinyl patch is shown in Figure 4. The ship in this case had the following history: Active for eight months, then

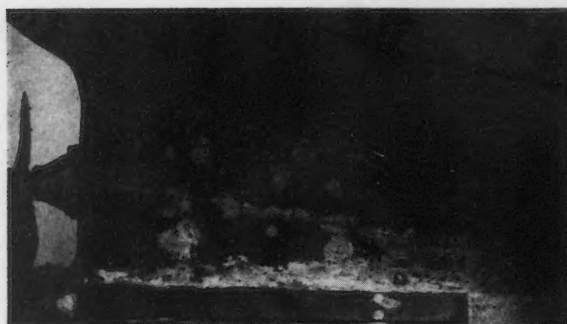


Figure 5—Blistering of vinyl paint around starboard anode of Y. C. Merrickville.

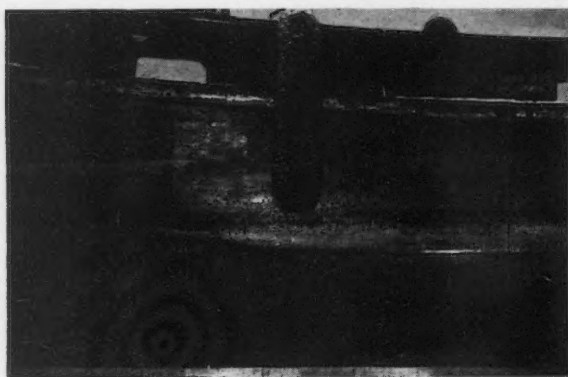


Figure 6—Port side midship view of Y. C. Merrickville. Note blister at right of photo.

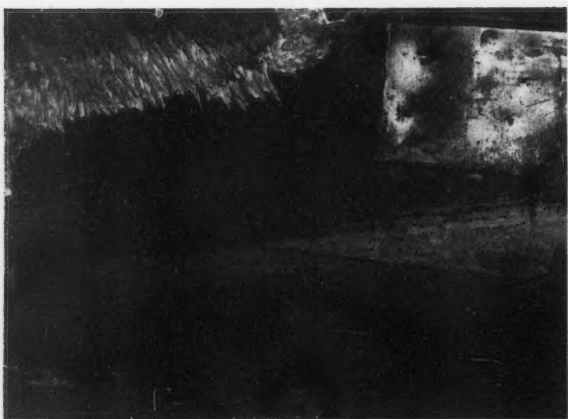


Figure 7—Y. C. Manville, port side bow showing fouling.

TABLE 1

TUG	Time from Date of Painting in Months	Remarks	Figure No.
Merrickville	5½	Blistering of paint, particularly port side. Paint stripping near port anode. No fouling on hull.	5 and 6
Manville	10	Fouling at bow and on starboard side. The antifouling coat in these regions had come off. No fouling on port side except at bow.	7 and 8
Listerville	13	Paint free of fouling and intact, except for some stripping in the immediate vicinity of the anode.	9 and 10

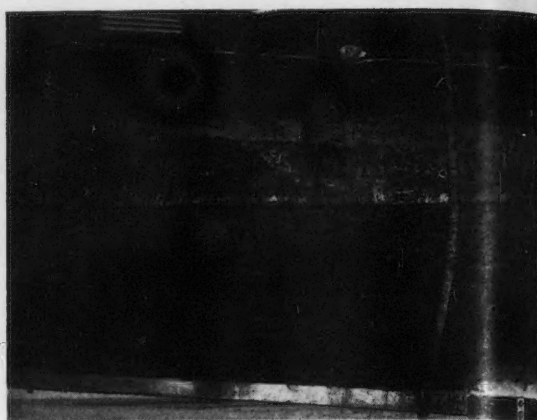


Figure 8—Y. C. Mannville port side midship section.

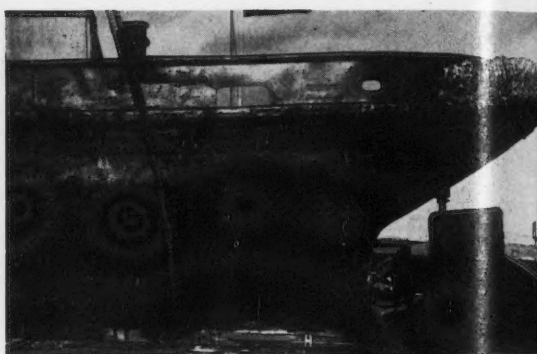


Figure 9—Y. C. Listerville showing vinyl coating on port side stern section. Fouling on rudder is due to accidental omission of anti-fouling coat on this section.

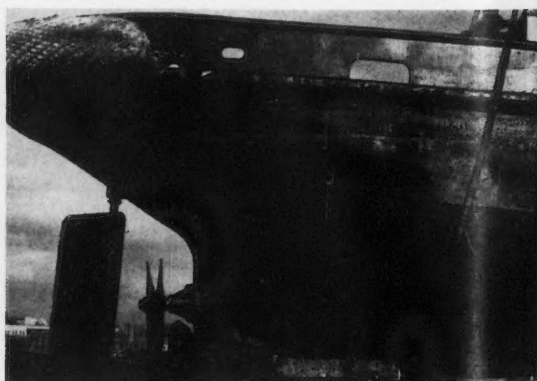


Figure 10—Y. C. Listerville starboard stern section.

berthed at a jetty for four months during the summer fouling season. The photograph clearly delineates the vinyl patch which is free of fouling except on the edge of the bilge keel where the paint has come off and on a few areas immediately adjacent to the anodes where the paint has stripped off and has been replaced by a calcareous deposit.

In addition to ship trials of vinyl patches on large active ships, trials were also run on small cathodic

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cally protected tugs where the entire underwater hull of 500 square feet area was coated. Four tests were conducted on three tugs, the Merrickville, Mannville and Listerville, the latter being painted twice. These tugs were active harbor tugs whose potential was checked periodically and, when necessary, the output of their protective systems was adjusted to keep the hull potential at the desired value.

The first trial was made on the tug Listerville. The hull, in this instance, was buffed clean, not sandblasted, and then painted with a complete vinyl system. The paint applied remained clear of fouling for eighteen months, including two successive summer growth seasons.

The three tugs, when used in subsequent trials, were cleaned, as described earlier and painted with complete vinyl systems. With two of the tugs, Merrickville and Mannville, short circuits developed in the cathodic protection system shortly after painting and undocking and the potential of these tugs was above the desired value for varying intervals of time. With Mannville, this interval was six months and with Merrickville, 2½ months. Results of inspection when the tugs were lifted out of the water are given in Table I, while photographs illustrating the main points of the results, are shown in the photographs taken at the time of inspection, Figures 5-9.

It is evident from the above results that provided the hull potential is maintained at about 840 millivolts or, very little, damage results to vinyl paints on cathodically protected ships. However, potentials higher than 1000 millivolts will damage vinyl finishes over a period of time and it is important therefore that cathodic protection systems on ships should include some method of controlling the protecting current. All cathodic protection systems fitted to Canadian Navy ships are controlled systems and potentials higher than the desired 840 millivolts should not occur in practice, except when faulty fitting of anodes causes shorting.

No inactivation by cathodic protection of the antifouling paints tested was observed. The main toxic

ingredient in the paints tested was cuprous oxide, except for the chlorinated rubber antifouling paints which contained mercury compounds.

Summary

The results of panel and shipboard trials indicate that vinyl paints satisfy the requirements laid down at the beginning of this paper for paints to be used on a cathodically protected hull, provided a controlled system is used and the hull potential is in the vicinity of 840 millivolts.

Acknowledgments

The author acknowledges permission of Defence Research Board and the Royal Canadian Navy for permission to publish this paper. He also acknowledges the cooperation of the Royal Canadian Navy, in particular the officers of the Naval Construction Department and of H.M.C. Dockyard, Halifax.

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A Technical Note

Temporary Ground Beds by the Roll*

VERY SERIOUS and expensive mistakes can be made, even by fully experienced corrosion engineers in guessing at the current required to cathodically protect an underground structure, say a pipe line, from corrosion.

The amount can be approximated by deciding on a recommended current density, and then the design of the ground beds and rectifier ratings can be made to fit. But this is a big gamble, especially on coated surfaces where the condition of the coating and the current requirements cannot be approximated. On bare surfaces, the distribution of the current cannot be anticipated.

The procedure recommended is to make a detailed current requirement survey, after which the ground beds can be designed with assurance. The rectifiers can be purchased with the known required current output and voltage to match the ground bed resistance.

A simple current requirement survey is the subject of this paper.

Usual Procedure

The technique is to install some sort of a temporary ground bed and use a portable source of DC power, welding machine, batteries, or small rectifiers. The temporary ground beds used in the past have varied from several reinforcing rods driven into the ground, buried plate steel or pipe, and even to steel highway guard rails about curves in the road.

There are several serious objections to such installations and inconveniences that result in effect to neglect on the engineer's part to conduct a proper survey.

Expense is incurred always in handling and installing materials for these beds. Labor and operations will include wages of the men, the welder and his helper, the welding machine, a truck, etc. A one-day survey requiring these costs will result in considerable expense. The bed should be removed after the survey, a task that sometimes requires excessive effort and always bad tempers. They should never be left in the ground.

The most serious objection, however, is that the resistances of these temporary beds are high, requiring high voltage power or resulting in low current output. In some cases expensive sets of special rods and DC generators are bought for these surveys.

Abstract

Household aluminum foil, spread out on moistened ground, or preferably in water or a damp ditch can be used satisfactorily as a temporary ground bed for making calculations of the current required to protect an underground installation. A 25-foot strip of aluminum will hold output constant for several hours, but for tests of 8 hours at 15 amperes or more, two 25-foot strips are recommended. Resistances as low as one-half ohm have been obtained and current output can be regulated by folding the foil back on itself.

One Solution

If something inexpensive could be used—inexpensive to install and remove, of light weight, easily accessible and still effective, then considerable money and time would be saved throughout the corrosion control profession. Resulting also would be better engineered cathodic protection installations made possible by the more reliable current requirements surveys.

A technique meeting these requirements is presented here for consideration. The material is common household aluminum foil, available at even the smallest of grocery stores now. A one by twenty-five foot roll will cost less than 50 cents usually.

For best advantage, it should be rolled out in water, a creek or water-filled barrow ditch. This gives a more evenly distributed current density, and permits easy removal after the test. However, satisfactory results have been obtained by wetting down a smooth path and molding the foil to the ground by patting it down firmly on the mud. Salt can be used to lower the resistivity if desired, but not in a cultivated field of course. A thin cover of loose dirt will hold the foil tight against the mud. This type of installation is difficult to remove because the foil resembles a fine lace after several hours of use and will tear easily.

A 25-foot strip will hold the output constant for several hours. However, for an 8-hour test at 15 amperes or greater, two 25-foot strips are recommended. The connection can be made by twisting the two close ends together.

Ground bed resistances as low as one-half ohm have been obtained and the current output can be reduced for constant voltage sources by merely rolling up the foil or folding it back on itself.

Conclusions

The result is one of the most convenient and effective tricks in the corrosion control trade. Many major problems probably have just such a simple solution, so this is a plea for all to share their ideas and discoveries.

* A discussion presented by B. J. Whitley, Jr., Tennessee Gas Transmission Co., Houston at the South Central Regional meeting of the National Association of Corrosion Engineers, Tulsa, Okla., October, 7-9, 1953.

Some Notes on Hydrogen Blistering*

HYDROGEN attack on carbon steel has been recognized for a long time. However, only in recent years has this attack been called to industry-wide attention, notably by Bartz and Rawlins¹ and by Effinger *et al.*² Work described in this paper was undertaken to add to the general knowledge on the subject.

Independently of the work by the Shell group,² tests or probes were devised in these laboratories

for measuring atomic hydrogen diffusion (Figure 1). The first type of tester was simply a sandwich of two pieces of $\frac{1}{8} \times 2 \times 6$ inch cold-rolled steel milled flat and silver soldered at the edges and to which a pressure gage fitting was soldered in communication with the flat crack between the metal pieces. The second type of tester was made by drilling and reaming bar stock and then forcing into the hole a smaller diameter piece of bar stock. Cap pieces were silver soldered to each end; one cap piece was fitted with a half coupling. A gage, screwed into the half coupling, read pressure of the practically volumeless crack between the two pieces of bar stock.

The hydrogen diffusion testers or "volumeless cells" described above provided a large area of discontinuity inside the bulk of metal, with the discontinuity or crack connected to a pressure gage. Volume of the cells was about 3 ml, most of which was accounted for by the pressure gage. The volume, of course, varied with the extent to which the gage was tightened. It was estimated that the volumes of the various testers all lay within 25 percent of the mean.

Procedure

Eight hundred ml of corrosive liquid in a 1000 ml beaker was kept in a constant temperature bath at 80 degrees ± 0.5 degrees F. The solutions used were prepared from reagent grade hydrochloric and acetic acids, distilled water and commercial cylinder grade hydrogen sulfide. One hydrogen diffusion tester was placed vertically in the beaker. The pressure gage on the tester was read at intervals to establish the saturation period and pressure build-up rate. The saturation period is defined as the time required for pressure build-up to begin. The tests were continued until the pressure reached 15 psi, or for a week or two if there was no pressure build-up.

In one test, a mild steel cylindrical tester fitted with a 1000 psi gage was allowed to stand in 2.4 percent HCl for nine days, with results shown in Figure 2.

In addition to mild steel, several testers were made of Type 304 stainless steel and a special electric furnace steel supplied by Timken Roller Bearing Co. The analysis supplied with the latter steel is given in Table 1.

Data obtained with the flat and cylindrical testers are listed in Tables 2 and 3.

Results and Conclusions

1. Under suitable conditions, high hydrogen pressure can be built up inside a metal within a short time. This is illustrated in Figure 2 which shows a pressure build-up to almost 1000 psi in seven days. The pressure

Abstract

Data were obtained on the diffusion of atomic hydrogen through several kinds of steel in acidic solutions. Where diffusion occurred, the presence of sulfide increased the diffusion rate. In an electric furnace grade steel, diffusion did not take place unless sulfide was present. Observations were made on the permanence of the sulfide surface associated with rapid atomic hydrogen diffusion.

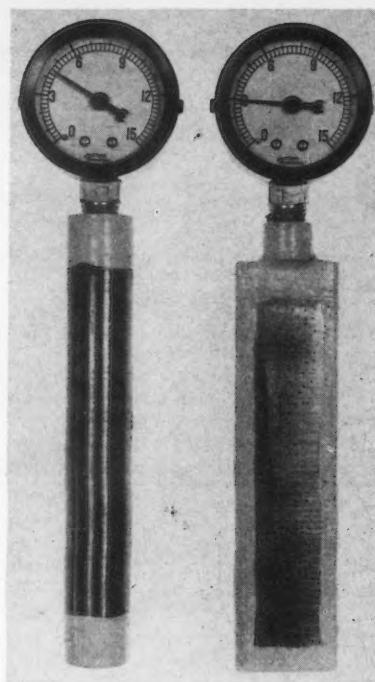


Figure 1—Cylindrical and flat "volumeless cells" used to study atomic hydrogen diffusion.

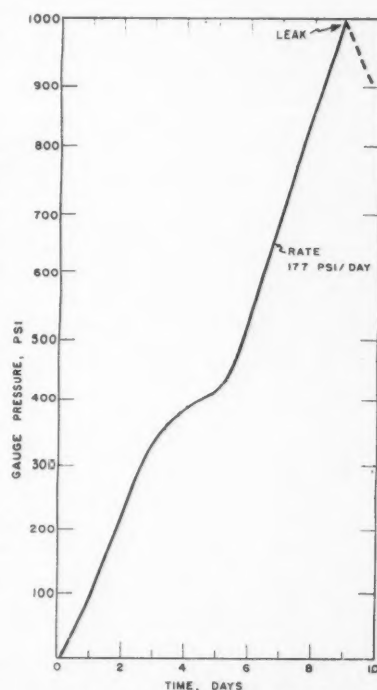


Figure 2—Pressure build-up in a cylindrical mild steel volumeless cell immersed in 2.4% hydrochloric acid, room temperature.

*Submitted for publication April 16, 1953 by Glenn A. Marsh, Research and Development Laboratories, The Pure Oil Company, Crystal Lake, Ill.

TABLE 1
Analysis of Special Electric Furnace Grade Steel*

Element	Percent Present
C.....	0.30
Mn.....	0.57
P.....	0.018
S.....	0.018
Si.....	0.62
Cr.....	1.20
Ni.....	0.20
Mo.....	0.49
Va.....	0.29

Annealed from 1650 °F. Brinell 183-187.

* Supplied by Timken Roller Bearing Co.

TABLE 2
Data Obtained with Flat SAE 1020 Steel
Hydrogen Diffusion Testers at 80°F

No.	Solution	Pressure Build-Up, psi/hr	Saturation Period, hr*
1.....	1.0% HCl	0.57	38
2.....	2.4% HCl	0.65	12
3.....	4.7% HCl	0.36	<1
4.....	5.0% HCl	0.47	<1
5.....	10 % HCl	0.60	<1
6.....	10 % HOAC	0.12	**

* Time required for pressure build-up to begin.

** Not determined.

build-up in Figure 2 would no doubt have been much more rapid if sulfide had been present.

2. The pressure build-up in flat mild steel testers immersed in hydrochloric acid solutions appears to be independent of acid concentration over the range from 1 to 10 percent. (Table 2.) The pressure build-up in a tester immersed in 10 percent acetic acid was one-fifth as rapid as the build-up in hydrochloric acid. This is a surprisingly high build-up rate in view of the fact that the 10 percent acetic acid has a hydrogen ion concentration equal to that of about 0.04 percent hydrochloric acid.

3. Cylindrical testers in 2.4 percent hydrochloric acid showed rapid pressure build-up in the case of mild steel but no pressure build-up in the case of Type 304 stainless steel or the electric furnace steel of Table 1.

4. Mild steel testers showed rapid pressure build-up in water saturated in hydrogen sulfide and in sodium-calcium chloride brine saturated in hydrogen sulfide.

5. Electric furnace steel testers developed pressure build-up in water or brine saturated with hydrogen sulfide. This is of special interest because this steel

TABLE 3
Data Obtained with Cylindrical Hydrogen
Diffusion Testers at 80°F

No.	Metal	Solution	Pressure Build-Up, psi/hr	Saturation Period (if any) hr
1.	SAE 1020 Steel	2.4% HCl	7	1
2.	304 SS	2.4% HCl	0	....
3.	Electric Furnace Steel (E. F. Steel) cf. Table I	2.4% HCl	0	....
4.	SAE 1020 Steel	H ₂ O Sat'd with H ₂ S	1.5	3
5.	304 SS	H ₂ O Sat'd with H ₂ S	0	....
6.	E. F. Steel	H ₂ O Sat'd with H ₂ S	0.2	16
7.	SAE 1020 Steel	10% NaCl + 2% CaCl ₂ + Sat'd with H ₂ S	1.5	3
8.	304 SS	10% NaCl + 20% CaCl ₂ + Sat'd with H ₂ S	0	....
9.	E. F. Steel	10% NaCl + 2% CaCl ₂ + Sat'd with H ₂ S	0.7	14
10.	SAE 1020 Steel	1% HCl	0.8	6
11.	SAE 1020 Steel	1% HCl + 0.33% Na ₂ S • 9H ₂ O	4	0.5
12.	Tester No. 11, not washed	1% HCl only	5	0.5
13.	Tester No. 11, washed in 1:1 HNO ₃ after test No. 12	1% HCl	0.8	6
14.	E. F. Steel	1% HCl + 0.33% Na ₂ S • 9H ₂ O	1.5	1
15.	Tester No. 14, rinsed in 1 percent HCl	1% HCl	1.5	1
16.	Tester No. 14, rinsed in 1:1 HNO ₃ after test No. 15	1% HCl	0	....

was not permeable to atomic hydrogen originating from hydrochloric acid. There was no noticeable corrosion in the hydrogen sulfide water but there was rapid corrosion, evidenced by hydrogen evolution, in the dilute hydrochloric acid.

6. Once a susceptible steel has been exposed to sulfide, the rapid pressure build-up associated with sulfide is retained even when the metal surface is washed with dilute hydrochloric acid and then immersed in hydrochloric acid. This suggests that water washing of susceptible vessels may not always be effective as a practical means for preventing hydrogen attack. In some cases where a sulfide surface has been formed it may be necessary to remove the sulfide with an active oxidizing agent.

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Laboratory Methods for Evaluation Of Inhibitors for Use in Oil and Gas Wells*

By E. C. GRECO* and J. C. SPALDING, JR.**

Abstract

The need for a compilation of methods for laboratory evaluation of oil and gas well corrosion inhibitors was recognized at the national meeting of the NACE in 1952. At that time, the chairman of TP-1 appointed the authors as a committee to contact those companies, both producing and chemical manufacturing companies, known to be interested in the problem of oil and gas well inhibitors. Subsequently, inquiries were sent to all major producing companies that were members of NACE, and several of the chemical manufacturing companies that were known to be working on the development of oil and gas well corrosion inhibitors. As a result, methods used by some ten major producing companies and four chemical manufacturing companies along with methods used in one of the research departments of a university were gathered. The general classification of tests used in the laboratory are presented along with some meager information as to the correlation of such tests with field experience.

The short range purpose of this article is to present to all interested in the problem the possible methods that may be used in the laboratory for such evaluation work and at the same time to solicit from all those receiving this report information that may lead TP-1 to the adoption of or, at least, recommendation of standardized laboratory procedure. The latter action, of course, is the long range purpose of this work.

Data gathered from companies canvassed indicate the majority working in this field still rely upon corroding systems as set up in the laboratory (whether reflecting field conditions or entirely synthetic) to produce weight loss upon coupons made from material expected to be used in the field. In addition, there are a few companies working on such varied methods of laboratory evaluation as the determination of: 1. film resistivity; 2. hydrogen evolution; 3. drop size ratio, etc.

One discussor deals with static tests and sessile drop tests. He points to several theoretical and practical objections to the drop test, asserting that the drop test is unreliable because wettability criteria cannot be translated always into inhibitor efficiencies. The question of interfacial tensions between metals and fluids is considered with the conclusion that the distinction between adsorptive and oil wetting inhibitors is not clear. The discussor does not believe that contact angle measurements can be used theoretically to predict the extent of oil or water wetting of a surface or that it can be assumed that oil-wet surfaces will not corrode.

A second discussor outlines the methods used by one company in determining the efficiency and economics of inhibitors. The principal objection the discussor has to the committee's aim is that the number of variables in producing well systems are so great that laboratory tests cannot be considered conclusive until backed by field experience. Tests with wetting agents are described in which the rate of adsorption of water dispersible inhibitors may be checked. The discussor also says that the effectiveness of an inhibitor should be measured by the cost of well equipment that must be replaced, pointing out by examples several instances when the cost of equipment replaced was materially reduced as a result of the use of an inhibitor.

He concludes selection of inhibitors by the drop-size ratio or oil-wetting tests is reliable for oil and gas wells but not for gas condensate wells. Speed of the drop size ratio method and the possibility of quantitative recommendations are assets also. This factor is important as indicated by a study which showed a range of inhibitor costs per barrel from \$0.009 to \$0.224.

DURING the 1952 National Meeting of the National Association of Corrosion Engineers, the subject of laboratory testing of corrosion inhibitors for use in oil and gas wells was discussed by the Technical Practices 1 (TP-1) Committee. It was proposed that a reasonably simple laboratory method might be designed or found which could be adopted as a standard corrosion inhibitor test. If such a method were available it could be used as a "yardstick" to measure the relative effectiveness of new inhibitors before testing them in the field. By means of the standard method new inhibitors could be compared as to effectiveness relative to other inhibitors of known field performance histories. With many laboratories using the same method, better comparisons of data secured from different sources would be possible.

The authors are fully aware of the large discrepancies existing between field and laboratory test data. Due to the very large number of variables one must consider when dealing with oil and gas well corrosion problems, it is extremely difficult to design a laboratory method which will reproduce precisely well conditions.

Before a standard method can be selected, two situations differing in general nature must be recognized—the corrosion systems found in gas condensate wells as differing from those found in sour crude oil wells. In the above cases somewhat different corrodents and mechanisms of corrosion are involved. Since the variables in these two systems are not identical, different methods may be selected. The requisite standards to be met by each of the methods chosen are as follows:

1. It must, as nearly as possible, reproduce conditions existing in the well system involved.
2. Equipment must be relatively simple.
3. Sufficient test data must demonstrate the reproducibility of results obtained using the standard method chosen.

A selected method might be used as a standard of measurement by which one might say of an inhibitor: it is better, it is equal to, or it is not as good as inhibitor X for which we have sufficient field experience. Data gathered on the performance of an inhibitor

*This article is a condensed version of the paper presented at the Ninth Annual Conference and Exhibition of the National Association of Corrosion Engineers at Chicago, March 16-20, 1953. The full report on the authors' findings has been published for and circulated among members of NACE Technical Practices Committee 1 interested in inhibitors and is not available for general distribution. The committee, however, is interested in receiving additional information on methods used for screening and testing inhibitors and any who have useful information are invited to write to either of the authors. Persons interested in participating in the work of the committee are urged to communicate with the authors or with NACE Central Office, 1061 M & M Building, Houston 2, Texas.

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TABLE 1—Producing Companies Testing Methods

Company	
A	No laboratory testing
B	No laboratory testing
C	No laboratory testing
D	1. For condensate, weighed coupon is subjected to a synthetic brine in rotating bottle test. Bottle purged with CO ₂ and capped. 2. Also use spinning disc test and corrosion fatigue testing (Kraus machine).
E	Coupons are exposed to simulated well conditions in a circulating system which can be evaluated in temperature and pressure. System is completely evacuated.
F	A revolving wheel apparatus carries sealed flasks with weighed coupons. Flasks are evacuated. Various corrosive systems may be tried with or without inhibitors.
G	Test coupons are placed in jars and shaken in machine. No effort made to preclude oxygen.
H	Synthetic test solution is used in a sealed flask with CO ₂ , CO ₂ and acetic acid are used to control deaerated solution to standard conditions. Sulfide test uses 10% salt water, swept with nitrogen, and saturated with H ₂ S to desired concentration. Tests used since 1947 and 1944 respectively. Excellent correlation with field results.
I	1. Sessile Drop size ratio tests gives rapid evaluation of inhibitors which inhibit by making steel "oil wet," testing attempted. 2. Weight loss tests conducted in presence of air. No H ₂ S system. System is oxygen free. Inhibitors are classed as poor, fair, or good.
J	1. Pearson Bridge used to determine local corrosion current on steel specimen (1020) in corroding medium, and suppression of current in presence of certain types of inhibitors. Also used to determine resistivity of adsorbed inhibitor films, rate of adsorption and desorption, and tenacity of film. 2. Weight loss tests in rotating wheel with glass containers gives some correlation with above tests. 3. Sessile Drop size ratio tests also used.
K	1. Conventional weight loss tests. 2. Drop size ratio tests.

TABLE 2—Manufacturers Testing Methods

Company	
A	No information
B	No information
C	Using adsorption isotherm methods, rate of Hydrogen evolution methods, and potentiometric methods (No details).
D	Test to compare one inhibitor to another only, using steel in 15% HCl with inhibitors.
E	1. Static water drop test 2. ASTM D665-47T turbine oil rust test (Temperature=80°F) 3. Bottle test used with petroleum ether and distilled water. 1020 steel coupon is observed only for rust.
F	Swept flasks are used to contain corrodent into which steel coupons are placed. Weight losses are measured over 7 days.
G	A multi-beaker stirrer is used to hold a number of steel coupons. A hood lowered over the whole mechanism gives desired environment.

TABLE 3—Laboratory-Field Correlation

Inhibitor	%	Lab Test* (#/MMCF)	Field Test (#/MMCF)
1	.01	0.9	1.0
2	.005	0.5	0.7
3	.03	0.2	0.3

* Calculated on basis of a typical well producing 30 bbl. of condensate and 2 bbl. water per MMCF.

Data secured by weight loss method where a 4-oz. sample bottle is filled with 50 ml kerosene, 10 ml synthetic brine including 0.1% acetic acid and purged with carbon dioxide after inserting a sand blasted coupon. It is sealed and strapped to a wheel rotating at 60 rpm for 17 to 19 hours.

TABLE 4

	MPY		% Protection	
	Lab	Field	Lab	Field
Blank	2.81	24.6	—	—
Inhibited	1.10	1.9	62	93

Data secured by weight loss method where a coupon is exposed to a specific environment with known concentrations of an inhibitor as compared to weight loss of coupon exposed in same environment without inhibitor.

tor of unproved value using a standard laboratory method will certainly provide information quite valuable to the corrosion engineer called upon to decide whether an inhibitor has merit or should not be considered for field testing. The selection of a laboratory

method reproducing conditions existing in the well, employing simple equipment and having the necessary reproducibility of results, is deemed by the authors to be a logical approach to the Standard Laboratory Inhibitor Testing Method. The selection of such a standard would certainly not preclude more elaborate laboratory investigations by any interested company. However, the standard method could be used as the primary criterion for evaluating inhibitor performance.

As a preliminary to selecting this standard method, the authors were charged with responsibility for conducting a survey which might yield a method that could be chosen as the standard. In order to conduct the survey, questionnaires were prepared and mailed to 25 companies. These included both oil and gas producing companies and inhibitor manufacturing companies. Eighteen replies were received—eleven from producing companies (Table 1) and seven from manufacturing companies (Table 2) interested in the development of corrosion inhibitors. The replies varied from a simple statement to the effect that no laboratory test was being used to answers giving descriptions of elaborate methods employing complex equipment. In general the methods reported can be divided into three broad classes as follows:

1. The coupon weight-loss method
2. The electrical or potential measurement method
3. The Sessile drop or drop size ratio method.

Of the eleven producing companies which sent replies, three rely upon field testing while eight use some modification of the coupon weight-loss method. The coupon weight-loss methods reported varied from a simple static immersion of the coupon in a corrosive medium to complicated systems designed to reproduce well conditions.

Of the seven manufacturers who replied, two declined the request for information, one stated that they were using various methods but offered no details and four submitted the methods used in their laboratories. Of the four companies submitting methods, two use procedures similar to those in use by the producing companies and two use quite different procedures.

A summation of the results of the survey is as follows: Of eighteen companies offering replies three companies reported no laboratory method; three reported laboratory methods but offered no details or descriptions; two reported methods which compare one inhibitor with another in corrosion systems entirely different from systems found in oil and gas wells and ten reported methods in which coupons are subjected to a corrosion system similar to those found in sour crude oil or gas condensate wells.

Thus far discussed are only the types of tests used in the laboratory now. The obvious question is, "Do they mean anything?" In other words, regardless of the type of laboratory system being used, its complexity, its duration, its cost, or the data that results therefrom, can this information be correlated with information that will lead to selection of the most

efficient, the cheapest and the most readily available inhibitor for use in producing operations? Actually little more than acceptance of obtainable data from producing companies can be accomplished now. As a typical example of this see Table 3, in which three inhibitors were tested in the laboratory and their minimum effective concentrations determined. Note that based upon a typical well producing 30 bbl. of condensate and two barrels of water per MMCF, calculations show that a corroding system would lose from .2 to .9 pound of iron per standard million cubic feet according to which of three inhibitors were used. Following this a field test was made and results from flow line coupons indicated that the corroding systems lost from .3 to 1.0 pound of iron per standard million cubic feet. Note the close correlation between laboratory predicted and actual results. This is a prime example of what can be done in predicting corrosion rates by laboratory testing and screening. Refer to Table 4 giving data on an inhibitor tested in the laboratory and found to give some 62 percent protection. In the field this inhibitor was found to give .93 percent protection. However, the corrosion rate indicated in the laboratory and that experienced in the field agree very closely. The wide difference noted in the protection measured in the laboratory compared to that obtained in the field is due mainly to the very high corrosion rate obtained from field specimens (uninhibited) as compared to the coupon test blank corrosion rate obtained in the laboratory. This wide variance can be attributed to field conditions impossible to reproduce in the laboratory.

Analyzing the foregoing, the authors believe that a standard laboratory method can be found or developed which will fulfill the requirements stipulated in this report and that this standard method will lead to a better evaluation of inhibitors for use in gas and oil wells. The authors are not offering a standard method at this time, merely submitting the results of the survey along with a few pertinent remarks. It is recommended that the chairman of TP-1 appoint a subcommittee to undertake the study and evaluation of the various methods which have been presented thus far to the authors. The authors thank each of the companies which aided in obtaining the data described herein. It is hoped that the information presented will lead to a more generally accepted standard method for evaluating corrosion inhibitors. Everyone who reads this report is extended an invitation to present suggestions, ideas, and criticisms which will be of benefit to those charged with the task of developing the standard method.

As a result of the above survey and discussion of this subject at the 1953 National NACE Meeting in Chicago, the authors have been appointed as co-chairmen of a subcommittee (TP-1K) of Technical Practices Committee 1. This subcommittee has held its initial meeting and is presently engaged in the task of developing a standard laboratory screening method. Anyone desiring further details on the methods obtained during the above mentioned survey or desiring to contribute the details of a method of laboratory evaluation and/or screening, or to com-

ment on the above presented methods, or to present data correlating laboratory testing and field evaluation are invited to address such correspondence to either of the authors. Presentation of further data and discussions on this subject are scheduled at the NACE Kansas City conference in March 1954.

DISCUSSIONS

Discussion by Charles M. Blair, Jr., Petrolite Corp., Tretolite Div., St. Louis, Mo.:

The authors of this paper have performed a valuable service. The petroleum industry needs more rapid and reliable methods for evaluating inhibitors for various applications and the information presented here should make for faster progress in filling this need.

As is to be expected at this stage of development there is a healthy diversity of approaches to the problem of evaluation of inhibitors. It is the purpose of the present discussion to mention some of the dangers in relying on indirect, and, particularly, on static test methods and to consider the implications of surface theory in analysis of data obtained from studies of drops.

The use of data obtained by the so-called "drop-size ratio" method, described in Appendix F* and subsequent discussion for the prediction of the activity of inhibitors appears to this writer to be predicated on two unjustified assumptions. Apparently it is assumed, first, that drop-size ratios give information as to the phase which wets the metal surface and secondly, that oil-wet surfaces will not undergo corrosive attack. The lack of a scientific basis for these assumptions may explain the failure of the method to correlate with field results in condensate wells and many oil wells.

Measurement of the dimensions of a very small oil droplet in contact with a solid surface and an aqueous phase permits one to calculate the approximate advancing contact angle for the oil phase under static equilibrium conditions. This value, combined with the oil-water interfacial tension, permits a calculation of the difference between solid-water and solid-oil interfacial tensions, a figure of thermodynamic significance in analyzing some static wetting phenomena.

Even leaving out of consideration the time and experimental conditions required to obtain true equilibrium between phases (particularly when using an oil containing micelles of surface-active agent), it should be noted that the very existence of a contact angle (other than zero) requires a condition in which both oil and aqueous phases are in contact with the surface. Further, the value of the angle gives no information about the relative areas of oil-wet and water-wet surface and no information about the rate of approach to the conditions of equilibrium.

An additional theoretical weakness of the method arises from the fact that it is static. In practical applications of inhibitors the usual concern is with dynamic (flowing) conditions. If the dynamics of a wetting process are to be analyzed in terms of inter-

* A part of the minutes of NACE TPI-K but not included in this article.

facial tensions, then it is clearly necessary to employ dynamic values of tensions and the related angles. It is well known that the dynamic interfacial tensions of surface-active agents may (and usually do) vary greatly from the static values. At present it appears to be impossible to predict the relative value of surface-active agents in dynamic wetting processes. For example, Moilliet and Collie ["Surface Activity," Spon Ltd., London (1951)] point out that "the general surface-activity of C_{16} paraffin-chain salts, under equilibrium conditions, is considerably greater than that of the C_{12} homologues but the latter are well known to be better technical wetting agents in the displacement of air by aqueous solutions from textile fibres. It seems almost certain that the answer lies in part in the more rapid adsorption of the short-chain agents at the relevant interfaces."

Aside from the problem of actually determining whether oil wets a metal surface under field conditions, there is no certainty that oil-wetted surfaces will not undergo corrosion. Experiments in the Petrolite laboratory have indicated that in some systems at least, oil-wet portions of steel were more severely attacked than adjacent water-wet areas. Certainly there appears to be no reason, *a priori*, to assume that iron in an oily phase is invariably cathodic or unreactive.

The available evidence indicates that organic corrosion inhibitors adsorb at the metal surface to form a layer which interferes with the corrosion process. [See, for example, Butler, "Electrical Phenomena at Interfaces," Macmillan, New York (1951), p. 67, et seq.; Hackerman and Schmidt, *J. Phys. & Colloid Chem.* 53, 629 (1949); Blair, *Corrosion*, 7, 189 (1951)]. If this layer is stable in the presence of the fluid in contact with the metal, then as a thermodynamic requirement, the interfacial tension between the metal and the fluid is decreased. Where both oil and water are present, as in a typical oil well, it is likely that both the metal-water and metal-oil interfacial tensions are lowered, since otherwise a film stable to both fluids would not exist. Stated formally,

$$T'_{ws} < T_{ws} \quad T'_{os} < T_{os}$$

where T_{ws} and T_{os} are the original metal-water and metal-oil interfacial tensions and the primes indicate these tensions after addition of inhibitor.

Now the thermodynamic requirement for the complete wetting of an extended metal surface by oil with the exclusion of the water (immersion wetting) is that

$$T_{ws} - T_{os} > 0$$

and that no contact angle exists. On the addition of an adsorbable material to a system which is only incompletely oil-wetted, the surface may then become water-wet, oil-wet or remain partially wet by both phases depending upon the relative effect of the adsorbed layer on T_{ws} and T_{os} . However, it is to be noted that a corollary is that if an added surface active material results in an oil-wet surface, $T'_{os} < T_{os}$ and, by Gibbs rule, adsorption must occur at the solid-oil interface.

Thus, the distinction made in Appendix F between "adsorptive" inhibitors and "oil wetting" inhibitors is hardly a clear one. An oil wetting agent must be adsorbed, but it may not be an inhibitor. On the other hand, an organic inhibitor apparently is adsorbed but may not result in oil wetting.

Many organic materials are known to adsorb at metal-water or metal-oil interfaces to form films which do not effectively inhibit corrosion, or, in fact, may be accelerators. Whether or not an adsorbed film is protective undoubtedly depends upon the structure of the film. The situation is analogous to the adsorption of surfactants at an oil-water interface. Positive adsorption can be detected by a lowered interfacial tension, but no prediction can be made from this as to whether the agent will stabilize a water-in-oil emulsion, an oil-in-water emulsion or no emulsion at all.

Summarizing, static contact angle measurements cannot be used theoretically to predict extent of oil or water wetting of a surface, particularly in a flowing system. It cannot be safely assumed that oil-wet surfaces will not corrode. Both water wetting and oil wetting agents for metal must be adsorbed at a metal-liquid interface. It appears that positive adsorption at a metal surface is a necessary but not a sufficient requirement for an organic inhibitor.

Discussion by H. E. Waldrip, Gulf Oil Corp., Houston:

The authors are to be commended for their presentation of a very interesting and informative paper.

In the first place, it is no easy task to obtain by questionnaire the necessary information and data. Also, in a paper of this type the authors, as reviewers of another's method, do not have the same zeal regarding a given method as the originator. Therefore, it is possible that some offense may be taken. This paper can be considered a starting point from which to build acceptable laboratory testing methods.

There is no doubt but that it would be desirable to have standardized methods for the evaluation of inhibitors. While this is very desirable, I doubt very

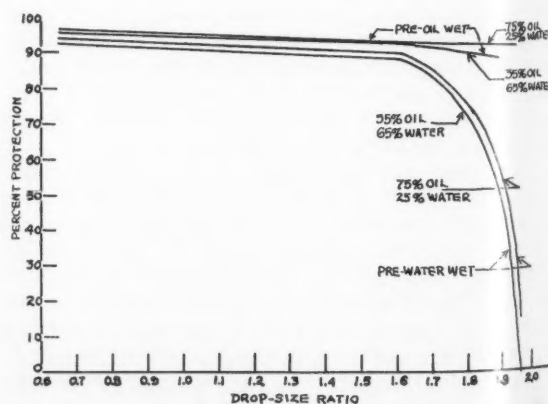


Figure 1—Correlation between percent protection and drop-size ratios of sweet crude oil and brine.

much whether it is very practical, especially at this time. There are so many variables in the methods by which the inhibitors function and in the various types of production that it is doubtful if even a few methods would apply to all conditions. To expand this, inhibitors can be water-soluble or dispersible, oil-soluble or dispersible, or may be carried mechanically by either. They may function as adsorptive agents or by virtue of surface activity. They may be non-ionic, cationic, or anionic. They vary in their rates of adsorption and desorption. The stability of an inhibitor is important but not often given much attention. Inhibitors may create adverse operating problems such as emulsion formation, wax deposition, or plugging due to the formation of reaction products, and many others. Inhibitors must be in such form as to be in a usable state in any climate.

The variables in types of production are also many. In condensate wells the production may be single phase in part of the producing string and three phase in other parts. The solubility and possibly the rate of desorption could be vastly different on the same inhibitor in condensate than in crude oil. The effect of the greater velocity in gas wells over that in oil wells on corrosion is uncertain. In sweet crude oil wells the choice of an inhibitor may depend upon the type of artificial lift used, upon the water:oil ratio and/or the gas:oil ratio. The same variables are present in sour crude production. In sour crude we are not dealing with a steel surface but with an iron sulfide one. This fact has been overlooked by some investigators.

Regardless of the method used for pretesting and selecting inhibitors, they cannot be accepted until they have been backed up by field testing. If favorable field tests result from the selection by a given laboratory method then that method has proved itself for that type of production.

Any method used for laboratory testing of inhibitors is in a state of flux. Actually the method reported by one laboratory on preferential oil wetting, as measured by the drop-size ratio technique, is obsolete. There have been refinements or modifications that have not as yet been released for publication.

Recently a phenomenon was discovered in the laboratory that is believed to be unique. This new development, in a sense, combines the drop-size ratio oil wettability method and the method using a galvanic corrosion cell apparatus. Four of the most efficient water soluble or water dispersible adsorptive agents, as selected by the latter method, were studied for their effect on the wettability of crude oil. Using the regular apparatus described in Appendix F for measuring the wettability of oils, 10 ppm of the water dispersible adsorptive inhibitor was added to the brine in a glass cell. The specially prepared steel specimen was placed in the cell. Oil drops of untreated crude were placed on the steel surface as usual. In the course of this investigation it was found that the interval of time that the steel surface was in contact with the water containing the inhibitor was very important. Crude oil drops placed

on the steel surface immediately had practically no wetting. Drops placed after a period of 10 to 20 minutes in two of the four tests produced oil wetting, and drops placed after about one hour produced oil wetting in all four tests. This apparently gives a very easy method of checking the rate of adsorption of water dispersible inhibitors that also have an affinity for crude oil. Another interesting fact is that the order of efficiency as expressed by degree of oil wettability is of the same order as determined by the corrosion cell method. It is very odd to see several degrees of wettability of the same oil on a steel surface surrounded by the brine containing the inhibitor. It is of interest to mention that upon tipping the steel plate the drops having no wettability do not roll or become dislodged even when the steel plate is rotated 180 degrees. This is a case where the method that depends on the angle of tipping the steel surface until the drop slides would be of no value as a measure of wettability.

This recent development opens up a new means of checking inhibitors and will be a very economical method provided it is proved in the field. Field treatment has been recommended using an inhibitor selected by this method. This is an example of a method of testing inhibitors remaining basically the same and yet opening up an entirely new field of possibilities. The galvanic corrosion cell apparatus was originally developed as a method of measuring down-the-hole pH, and was modified by adding the corrosion cell which permitted testing of water soluble or dispersible inhibitors.

Promiscuous field tests of all inhibitors should not be considered. It is time consuming and costly, especially if one is expecting protection which is not realized. Field testing of promising inhibitors, as selected by laboratory methods, should be encouraged. Accurate records of actual material replacements and total costs of such replacements, including labor, should be kept both before and during treatment. This is a far more reliable means of checking the effectiveness of inhibitors on oil wells than are coupons, analyses, etc. For gas condensate wells, caliper surveys, coupons, analyses and visual inspection all are of value in determining the efficiency of inhibition. In time, sufficient data will be obtained to gage the merits of the various laboratory screening methods of evaluating inhibitors.

As part of the test program in the checking of inhibitors in connection with sweet crude oils and their associated brines, using the shaking corrosion test method, the wettability of the oil after the test was measured. It was thought that a definite relationship existed between the amount of corrosion protection obtained and the wettability of the oil used in the test. To investigate this, all previous data obtained from sweet oil-brine corrosion studies were examined. The percent protection obtained was plotted against the drop-size ratio of the oil, measured after the completion of the corrosion test. The data were plotted for steel specimens that had been pre-water wet (in the brine in which the test was made) and pre-oil wet (in the oil in which the test was made). An excellent correlation was obtained, as

shown in Figure 1. It was thought that the same relationship would exist with sour crude but this could not be proved because of the erratic results obtained from the shaking corrosion test method. This was because of the possibility of air being present and affecting the corrosion rate of the hydrogen sulfide system. In order to determine if this same relationship existed between oil wettability and corrosion protection, a corrosive sour crude and its brine were tested by the drop-size ratio method. Very favorable oil wetting on an iron sulfide surface was obtained by selecting the most effective of several materials. Quantitative recommendations were made to treat the well and the results of this field test follow:

Field Tests:

1. A pumping sour crude well in the Sour Lake Field, Texas.

Treatment consisting of one pint of chemical per day was started 11-14-49. During a period of 18 months prior to treatment, 210 feet of tubing and 304 feet of rods were replaced because of corrosion. Shortly after treatment was begun, 92 feet of tubing were replaced and no further replacements have been made in over three years. In all probability this 92 feet of tubing should have been replaced prior to treatment and undoubtedly would have been had a Dia-Log survey been made. Without treatment the trouble frequency would very probably have increased in direct proportion to the age of the well equipment because of unchecked corrosion. This is seldom, if ever, taken into consideration in making comparisons. It is standard practice to take the well in its existing condition and begin corrosion inhibition treatment, making comparisons on a "before" and "after" basis. It is believed that costs are not nearly so significant as the actual material replacements.

For those who are interested in these figures, the average monthly cost due to corrosion prior to treatment was \$86.29; since treatment it has averaged \$16.30, including chemicals.

2. Sweet Crude Oil Flowing Well, Gwinville Field, Mississippi.

This is a high salt water producing well. A string of tubing was replaced after 2½ years' service because of corrosion. Treatment was started with an adsorptive type inhibitor on 8-17-48. A record of this well is given in tabular form:

Treatment	Amount	Time Treated	Average Iron Content of Water
None			260 ppm
Adsorptive "A"	1.5 gal/day	7 mos.	180 ppm
Adsorptive "B"	1.5 gal/day	1 year	180 ppm
Wetting Agent "C"	3.0 qts/day	3 years	110 ppm

It is not known how much of this is formation iron but a portion of it could be. No trouble has been encountered in the well because of corrosion during the more than four years of treatment. Without treatment, and assuming the original corrosion rate still held, the well would be about ready for the third change of tubing. No caliper surveys have been run on this well for danger of killing it. Judging from the iron content, the treatment causing the produced crude to preferentially wet the steel is more efficient than either of the adsorptive inhibitors.

3. Pumping Sweet Oil Well, Mallalieu Field, Mississippi.

This well was equipped to pump on 8-11-49 with a mixed string of ¾-inch and ⅝-inch Axelson No. 79 sucker rods. In less than one year's time one hole had occurred in the tubing and four rod breaks had resulted. One hundred thirteen ¾-inch Axelson No. 79 rods were installed on 7-26-51, and on 8-14-51 treatment was begun consisting of 2 quarts of an adsorptive inhibitor "B" per day. In the next seven months, until 3-28-52, four rod breaks had occurred and one hole was found in the tubing. A Dia-Log survey caused 28 joints of tubing to be removed. When the sucker

rods were removed following the adsorptive inhibitor treatment they were found to be deeply grooved from corrosion. On 3-28-52, 113 Bethlehem Type X sucker rods were installed and treatment changed to the type that causes the produced crude oil to preferentially wet the steel. One rod failure has occurred but it was strictly a mechanical break in the threads. The rod itself was found to be in perfect condition.

The iron content of the water before treatment was 330 ppm; during treatment with the adsorptive inhibitor it dropped to about 135 ppm, and with the present oil wetting agent treatment it has further dropped to between 110 and 115 ppm. The amount of iron present in the formation is not known. Again judging from the iron content of the produced waters, the preferential oil wetting type inhibition is only slightly better than the adsorptive type, but from a material replacement standpoint it is giving excellent protection, whereas the adsorptive type treatment was a complete failure. Field engineers report that in addition to eliminating tubing and rod replacements, no polish rods or pump parts, working barrels, etc., have been replaced because of corrosion. Without treatment, and with the adsorptive inhibitor, numerous polish rods, working barrels and pump parts were replaced because of corrosion.

4. Pumping Sour Crude Well, Sand Hills Field, West Texas.

Data on this well are presented below in tabular form.

Equipment Service		Material Replacements Average/Month	Repair Costs per Month
15 months prior to treatment:	Tubing	200'	\$210.00
	Rods	220'	80.00
Pump average service, 35 days			63.00
Average total replacement costs per month:			\$353.00
37.6 mos. adsorptive inhibitor B:	Tubing	112'	127.00
	Rods	96'	37.00
Pump average service, 49 days			50.00
Cost of inhibitor			42.00
Average total replacement and treatment costs:			\$258.00
3.1 mos. treatment w/oil wetting Agent "D":	Tubing	0	0
	Rods	0	0
Pump average service, 46 days			96.00
Cost of inhibitor			54.00
Average replacement and treatment costs:			\$150.00

While this test has not been in progress very long the results are promising. It is interesting to note that there have been no tubing or rod replacements since the preferential oil wetting type treatment was begun. The pump life of the same order as with adsorptive treatment.

Field engineers also ran coupon tests in this well. All tests were the result of 15 days' exposure. The results are:

	mpy Corrosion Rate
No inhibitor, first test.....	59.52
No inhibitor, second test.....	54.52
Adsorptive Inhibitor "B".....	6.46
Preferential Oil Wetting Agent "D".....	0.61

Present treatment consists of mixing the chemicals with five gallons of crude oil, injecting into the annulus and circulating for approximately one hour.

It is believed that the four examples of results obtained from field tests definitely show that the selection of inhibitor for both sweet and sour crude oil wells, based on laboratory tests using the drop-size ratio or preferential oil wetting method, are reliable. It should be stated, however, that this method is not satisfactory for gas condensate wells. Nor has it proven economical in very low gravity sweet crude oil wells such as the Smackover, Arkansas heavy or the heavy crudes such as are found in the Baxterville, Mississippi field. However, in the case of the Baxterville wells, dollar for dollar they give equal or better results than do the oil dispersable adsorptive

types. In these low gravity oil wells it is thought that water soluble or dispersible adsorptive inhibitors may be the answer. Several are being tested in the field but as yet no data have been accumulated.

Advantages of the Drop-Size Ratio Method

This method is relatively simple, requiring a minimum of apparatus. It is rapid; tests can be made and recommendations given within one day. It enables the operator to make quantitative recommendations. With the exact amounts known, the economics can be determined in advance. Quite often experienced operators can use the method to estimate the degree of corrosivity experienced in the production of the fluids being tested. This is based on the type and degree of staining or tarnishing occurring on the steel surface, especially immediately surrounding the oil drop. In making recommendations for field treatment, the initial dosage is sufficient chemical to cause the crude oil to have a drop-size ratio of about 1.00. This treatment is circulated for several hours and all steel surfaces are converted from water wet to oil wet. Once this is accomplished the treatment is reduced so that the drop-size ratio of the oil is 1.70 or less. This is sufficient to maintain the surface oil wet.

These arbitrary values are somewhat dependent upon the oil:water ratio of the well being treated. Theoretically, the higher percentage of water the well produces the greater must be the tendency of the oil to preferentially wet the steel. Normally the amount of corrosion increases as the water increases. In using the oil wetting type of inhibition the minimum or oil phase is being treated.

Continuous treatment is preferred, but this can be used only where communication exists between the annulus and the producing string and where the fluid level of the well is low. Where the fluid level is high, batch treatment must be used and production circulated down the annulus long enough for the treatment to reach bottom. A decided advantage of this type treatment is that the materials used, in addition to causing the crude oil to preferentially wet steel and iron sulfide surfaces, also act as excellent emulsion breakers. We have yet to receive an emulsion in the laboratory that could not be broken at room temperature with these oil wetting agents. This means that in some cases corrosion protection and emulsion breaking can be had for the cost of the corrosion treatment alone.

The value of being able to predetermine treating costs may not seem important, but recently the data taken from trial equipment reports of 13 wells in West Texas being treated with adsorptive inhibitors

were used to calculate the treating cost per barrel of produced crude and the results were amazing. It was found that the cost varied from \$0.009 to \$0.224 per barrel of crude and the average cost was \$0.0875. Even though in most cases fairly satisfactory corrosion protection was being obtained, the wide spread of inhibitor costs indicates that there is much room for investigation and improvement.

It is common practice for producers to adopt the use of an inhibitor on the basis of manufacturer's claims or upon its success in certain areas. Neither of these means is advisable. The foregoing discussion substantiates the merit of the preferential oil wetting method for selecting treatments. It is tailored to the well or field in question; it is quantitative, and as mentioned previously, the economics are known in advance.

The same type of data on field tests are needed to substantiate other methods. This will take time, but eventually the data will be supplied and then the laboratory methods can be accepted as proved means of selecting inhibitors for oil and gas wells.

Discussion by Richard A. Lowe, Shell Caribbean Petroleum Co., Maracaibo, Venezuela:

The point raised was whether the tubing which was shown on some slides as being corroded had been pickled before installation. The only reason for raising this point was that the form of attack appeared similar to some encountered where the mill-scale had caused a considerable increase in normal corrosion rates.

Discussion by Horace A. Cataldi, Chicago, Ill.:

One of the difficulties in the measurement of corrosion by crude oils is that arising from the slow reaction rates encountered in laboratory methods. One method which has not been mentioned in your survey is that which measures the progress of corrosion in terms of changes of the electrical resistance of the specimens. Recently this method was applied to the problem of estimating the corrosivity of crude oils for the API Sub-committee on Corrosion.¹ This method also has been applied in our laboratory in the study of corrosion by various liquids and gases at ambient and elevated temperatures and of the effect of oil and water soluble inhibitors, and appears applicable to the evaluation of oil and gas well corrosion inhibitors. Methods for following the corrosion continuously are described by A. Dravnieks.²

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Corrosion by Water at Low Flow Velocity*

By T. E. LARSON and R. M. KING*

UP TO THE PRESENT there has apparently been no organized program for studying corrosion by fresh water. No pattern has been established even to define a corrosive water under various conditions of use.

The saturation index,^{1,2} for calcium carbonate has been devised and applied with the intent of providing a thin, controlled scale or film of calcium carbonate on the metal surface, thereby reducing or preventing corrosion. The saturation index indicates the tendency toward, but not the rate of, deposition or solution of calcium carbonate in a water, and does not necessarily show corrosivity, a fact that many water works chemists have long recognized.

The current practice appears to be either: 1. To assume that a water is corrosive and to treat it whether necessary or not; or 2. To assume that it is not corrosive until "red water" troubles develop or equipment failure is experienced, and then to apply the corrective treatment that seems most likely to succeed.

In 1924 Whitman, Russell, and Altieri³ concluded from careful experiments with Cambridge, Mass., water that, in the pH range 4.1-10 at 22 degrees C and 4.3-9 at 40 degrees C, hydrogen ion concentration has no effect on the rate of corrosion, and the main variable in this pH region is the rate at which dissolved oxygen diffuses to the metal surface. This conclusion was not intended to apply to waters of other mineral character, but it has been variously misquoted or enlarged upon to imply that dissolved oxygen controls the rate of corrosion in natural waters. The latter interpretation of the Cambridge results was proved incorrect by Baylis⁴ in 1926. He demonstrated the practical value of calcium carbonate protection by controlled pH and the low solubility of ferrous carbonate at a pH greater than 8.

Because, in reality, each addition of caustic or acid to adjust the pH of Cambridge water produced a water of different mineral quality, the conclusions reached by Whitman and his colleagues need not be applicable to water of the same mineral quality as that at Cambridge or to potable waters in general.

Long experience has taught water works personnel the value of pH control for corrosion protection, but it has also shown that factors other than pH and dissolved oxygen influence corrosion rates. Data available in the form of mineral analyses have not been amenable to interpretation owing to the lack of experimental evaluation.

It is the purpose of this paper to demonstrate that water quality is a primary factor in corrosion (spe-

Abstract

It is postulated that water quality is a primary factor in corrosion by fresh waters, especially at low velocities, and that the influence of dissolved oxygen and pH on corrosion rates is secondary. Citing classic articles on pH adjustment, the authors say the conclusions reached by cited experimenters are true only for the water tested and cannot properly be applied generally to all waters. By means of an electrolysis cell the authors tested the effect on anodes and cathodes of passing through water moving at various low velocities an increasing volume of current and noted changes in the character of the water.

After the proportion of sodium chloride or sulfate reached a given value the corrosion rate was not influenced by further additions of the chemicals but was in proportion to the dissolved oxygen present. For specific chloride content corrosion rates might be considerably greater for solutions of low mineral content, leading to the conclusion the rate is controlled more by specific mineral quality than total mineral content. The inhibitive effect of bicarbonate was noted in both 3-day and longer tests. Relatively lower corrosion rates were experienced with nitrates.

Authors doubt the corrosion product adjacent to iron is ferrous hydroxide when carbonate or bicarbonate is present. Instead it is contended the initial corrosion product in fresh water is soluble ferrous chloride, hydrolyzed insoluble ferrous hydroxide being secondary.

cifically at low flow velocities) and that the influence of dissolved oxygen and pH on corrosion rates is secondary. It is believed that the data presented will provide a basis for comparison with information obtained in future studies and in practical experience.

Qualitative Studies on Ion Migration

An elementary investigation was begun in 1948, with the assistance of John Grench of the Illinois Water Survey Div., to obtain qualitative data on the water composition at the cathode and the anode, as affected by waters of different mineral composition. The investigation was designed to study the general water quality conditions that develop between two iron electrodes under the influence of an artificially impressed voltage to produce a current density of a limited magnitude. The electrodes were located at opposite ends of an electrolysis cell divided into nine 470-ml compartments by vertical, parallel porous aluminum plates (Figure 1). University of Illinois tap water was permitted to flow through the center compartment at a rate of 300 ml per minute, while in the remaining compartments the water was in a quasi-stagnant condition. No attempt was made to aerate the water or to exclude dissolved oxygen. The composition of the water is indicated in Table 1.

Progressive quality changes occurred in each compartment with increasing milliampere-hours of current consumption. The changes were particularly significant in the end compartments. The increase in pH at the cathode is shown in Figure 2, and the

* Reprinted from Journal American Water Works Association, Vol. 46, No. 1, 1-9 (1954) Jan.

* Head and Assistant Chemist respectively, Chemistry Subdivision, State Water Survey, Urbana, Ill.

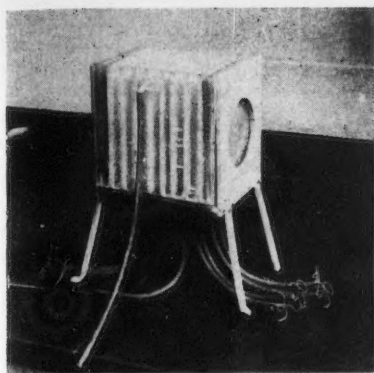


Figure 1—Experimental corrosion cell. The electrolysis cell is divided into nine compartments by aluminum plates between the two iron electrodes.

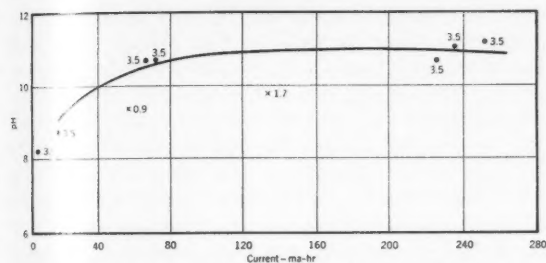


Figure 2—pH at cathode. The numbers at scattered points represent the current density in milliamperes per square foot.

accompanying reduction in calcium and magnesium in Figures 3 and 4. It will be noted that, at low current density, the pH was not affected so greatly for equivalent milliamperes-hour values, and, accordingly, magnesium precipitation did not occur during these tests.

The general distribution of calcium, magnesium and alkalinity concentrations in the various compartments is shown in Figure 5. The repeated loss of alkalinity toward the anode compartment was noteworthy.

In several tests, measurements were made on polyphosphate and silica concentrations in each of the compartments. When polyphosphate or silica was present originally in all the compartments, these tests showed a progressive decrease in the concentration of these ingredients in the compartments near the anode and the cathode. When all but the center com-

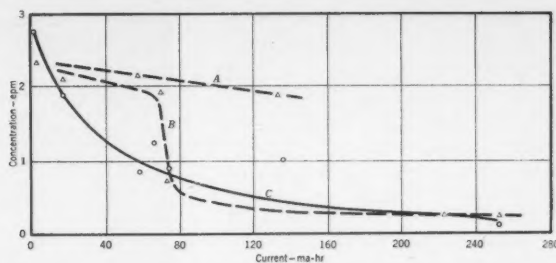


Figure 3—Magnesium and calcium concentration. Key: A—magnesium low current density (0.9-1.7) ma per square foot; B—magnesium, high current density (3.5 ma per square foot); C—calcium.

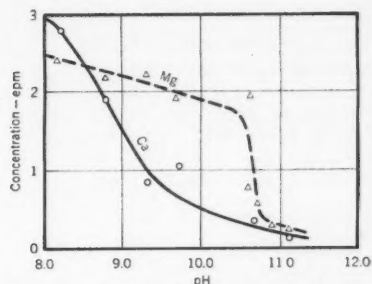


Figure 4—Concentrations at cathode. The curves show the concentrations of calcium and magnesium in the compartment adjacent to the cathode.

partments were free from polyphosphate, however, the migration of polyphosphate was definitely toward the cathode at low current density (0.4 ma per square foot), while, at high current density (4 ma per square foot), polyphosphate was found to migrate toward anode and cathode at equal rates.

It would have been interesting to continue these tests with water containing bicarbonate and more chloride, but it was decided to use a different approach to study the influence of bicarbonate and carbonate ions on corrosion rates.

Immersion Tests

As all natural waters contain bicarbonates in at least a small concentration, it was felt that consideration should be given to different proportions of bicarbonate and other anions in corrosion tests with controlled synthetic solutions containing known concentrations of sodium salts, eliminating the possible added influence of bivalent metal ions. Borgmann⁶ has indicated the relative corrosiveness of salts of numerous cations and anions, exclusive of bicarbonate and carbonate and largely in concentrations greater than that in natural waters.

The effect of carbonate ions as an inhibitor of corrosion was previously demonstrated by Evans⁸ in 1927. Mears and Evans,⁷ in 1935, described in detail the inhibiting effect of potassium carbonate on solutions containing potassium chloride. These data, however, concerned strips of steel partially immersed in solutions of known concentrations, and provided no information on the pH of the resultant mixtures of carbonate and chloride salts. In other words, although the potassium carbonate concentration varied,

TABLE 1—Tap Water Composition

Item	Amount	
	ppm	epm*
Iron (Fe).....	trace	....
Manganese (Mn).....	trace	....
Calcium (Ca).....	60.0	3.0
Magnesium (Mg).....	24.0	2.0
Sodium (Na).....	46.0	2.0
Silica (SiO ₂).....	19.0	....
Fluoride (F).....	0.3	....
Chloride (Cl).....	6.0	0.20
Nitrate (NO ₃).....	0.2	....
Sulfate (SO ₄).....	9.6	0.20
Alkalinity (as CaCO ₃).....	330.0	6.60
Hardness (as CaCO ₃).....	250.0	5.00
Dissolved oxygen.....	6.0	....
Temperature.....	55° F.	....
pH.....	7.4	....

* Equivalents per million.

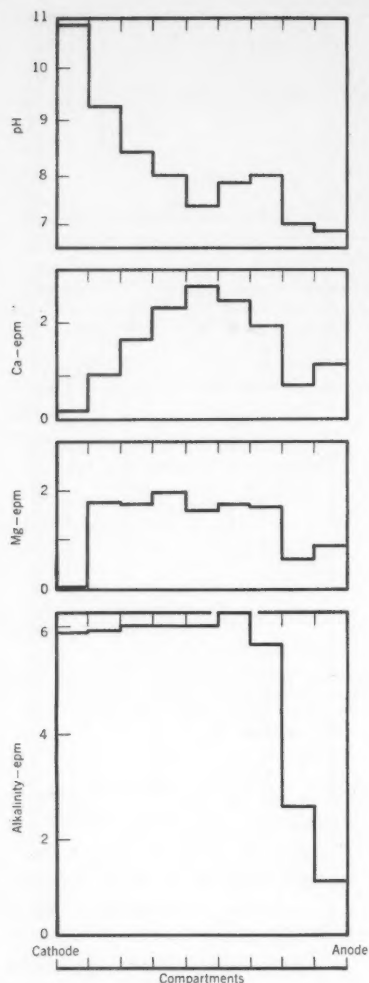


Figure 5—Concentrations in compartments. The curves show the concentrations (in equivalent parts per million) of alkalinity, magnesium and calcium as well as the pH, in the various compartments.

the pH was not held constant and it also varied for the various proportions. Therefore, both pH and carbonate ion variables affected the results.

Apparatus of the standard type⁸ for total-immersion tests of nonferrous metals was constructed for the studies (Figure 6). The $1\frac{1}{2} \times 3$ -inch specimens of 0.01-inch "black plate" steel (free from mill scale) that were used were reported to have the following composition (by percentage): C, 0.07; Mn, 0.30-0.45; P, 0.015 maximum; S, 0.050 maximum; and Si, 0.010 maximum.

The specimens were degreased in carbon tetrachloride; placed in a 5 percent solution of HCl and HNO₃ for 2 minutes; placed in concentrated HCl for 1 minute, rinsed in acetone and dried and weighed 48 hours before use. The edges were coated with paraffin, and a scratch was made on both sides of the specimen just prior to immersion in 18 liters of water for a 3-day test at a flow velocity of 0.085 fps at room temperature. A low velocity was deliberately

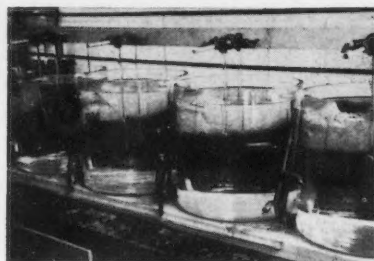


Figure 6—Total immersion test setup. The specimens used were of black plate steel, free from mill scale. The apparatus was of standard type.

chosen in order to simulate the conditions usually existing in as much as 25-50 percent of any municipal distribution system, including the service lines.

Various proportions of sodium bicarbonate and chloride were used at pH 7 and 9. Likewise, various proportions of sodium bicarbonate and sulfate were used at these pH values, and various proportions of sodium bicarbonate and nitrate were used at pH 7. Carbon dioxide was employed to control pH. The results are shown in Figure 7.

Discussion of Results

It was noted that, after the proportion of sodium chloride or sulfate reached a given value, the corrosion rate was not influenced by further addition of these chemicals. Also, the rate was of the same order of magnitude whether chloride or sulfate was used. The corrosion rates with these proportions were therefore assumed to be governed strictly by the dissolved-oxygen content of the water. In other words, if 15 or 20 ppm dissolved oxygen was present, the corrosion rate in this range may have risen, particularly with increasing proportions of sodium chloride.

It was repeatedly found that the corrosion rate was zero when a particular minimum of alkalinity was present in each test. It was also noted that an intermediate range of corrosion existed in which the rate was unpredictable under the experimental conditions. For example, of three specimens in a solution in this range, one may have corroded at a rate of 10 mg per square decimeter per day (mdd), while the two others may have corroded at a rate of 90 mdd in the same solution. In this range of water quality, the corrosion rate may have been inhibited or intensified, depending upon the extent and location of the corroded area of the specimen.

It was significant that, for any specific chloride concentration, corrosion rates might be considerably greater for solutions of low mineral content than for those of high mineral content, a finding that is contrary to the usual predictions. It may be concluded that corrosion rates are controlled more by the specific mineral quality than by the total mineral content.

It was also significant that, for some chemical compositions, corrosion rates appeared to be greater at pH 9 than at pH 7, while, for the others, the rates were unchanged. This also is contrary to the normal predictions on the corrosive tendency of water.

The relatively lower corrosion rates experienced with nitrates was surprising. Although a water that contains only bicarbonate and nitrate is a rarity, it should be of interest to make a further study of the effect of small concentrations of nitrate on corrosion rates in water containing various mixtures of chloride and bicarbonate.

Several spot tests with a 9-day immersion period yielded results no different from the 3-day data.

These data are specifically limited to dissolved-solids concentrations between 200 and 1200 ppm,

under the flow velocity and temperature conditions indicated. Figure 7, however, shows the corrosion rates experienced in a test series in which the combined sodium chloride and bicarbonate concentrations ranged from 60 to 210 ppm. Here again, it was noted that the bicarbonate exerted an inhibitive effect. In one group of tests with University of Illinois tap water at pH 7 (-0.4 saturation index), no corrosion was noted until 60 ppm NaCl was present.

Extreme caution is needed in interpreting these data or applying the conclusions to other conditions. Consideration must be given to the fact that, at the low velocities employed in these studies, the electrical migration of ions under the corrosion cell potentials plays a more important part in the process than the relatively slow diffusion rate of the dissolved oxygen. At a higher velocity, it might be expected that oxygen diffusion rates would be the more important factor. Also, the relatively high mineral content minimizes the effect of pH because the hydrogen and hydroxyl ion concentrations are relatively low.

One severe criticism of these data is that no attempt was made to distinguish between general corrosion and pitting. Where pitting occurs, the rate of penetration may be quite high, although the corrosion per square decimeter of the total surface may be no greater than in areas where general corrosion is experienced. Mears and Evans,⁷ however, have shown that pitting is less likely to occur where little or no anodic inhibitor is present.

The data obtained in the study under discussion appear to be particularly significant as a starting point or basis of comparison for future studies. Such investigations might involve lower quantities of dissolved oxygen, higher flow velocities, different temperatures, polyphosphates, silicates, free or combined chlorine and even calcium at concentrations approaching or exceeding its solubility as calcium carbonate.

Inhibition by Bicarbonate and Carbonate

Normally it is contended that, in air-saturated solutions which do not corrode, the dissolved oxygen has been responsible for the formation of an invisible oxide film. Evans⁹ cites many studies with electron diffraction and X-ray techniques which indicate films of ferric oxide. In fact, steel treated with pure oxygen for a sufficiently long period under proper conditions remains corrosion resistant until the film is broken or attacked.

It has often been stated that the corrosion product adjacent to the metal is ferrous hydroxide. It is extremely doubtful that this assertion holds true when carbonate or bicarbonate ions are present. Although the ferrous hydroxide theory may be perfectly correct when dealing with corrosion products derived from solutions of sodium chloride, the actual initial corrosion product is soluble ferrous chloride, hydrolyzed insoluble ferrous hydroxide being secondary.

It will be noted in Figure 8, however, that the solubility of ferrous carbonate is considerably less than that of ferrous hydroxide, although it is obviously greater than that of ferric hydroxide. This appears to indicate that any inconsistency in an

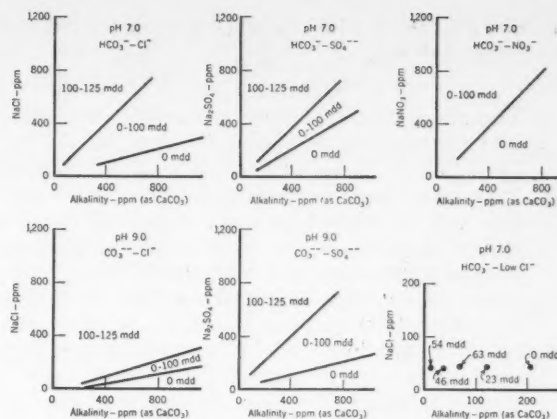


Figure 7—Results of total immersion tests. The experiments were conducted at room temperature and constant flow velocity (0.085 fps); the dissolved-oxygen content was 8 ppm. The solid lines represent boundaries of sectors in which the corrosion rates were shown.

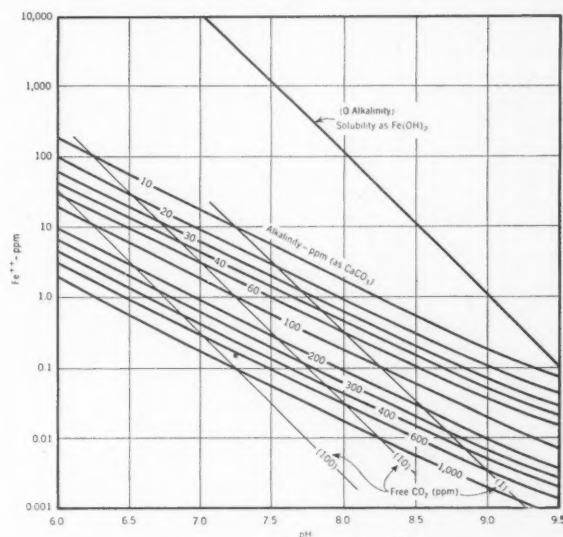


Figure 8—Solubility of ferrous ion. The solubility of FeCO_3 (solubility product, 2.11×10^{-11}) is considerably less than that of ferrous hydroxide in natural waters.

oxide coating would be protected immediately by ferrous carbonate rather than ferrous hydroxide.

Reconsidering the data that showed greater corrosion rates at pH 9 than at pH 7 for the same mineral quality—and accepting the assumption that ferrous carbonate provides an inhibitory film—the increased corrosion rates at pH 9 can be explained by the fact that ferrous hydroxide is more readily formed at the higher pH and is also more readily oxidized. Such localized precipitates adhering to the metal provide a physical barrier to oxygen diffusion and permit the metal surface underlying them to become anodic to the exposed surface. When sufficient alkalinity (not OH^-) is present, however, the flaws in an oxide coating are protected by ferrous carbonate before the ferrous ion concentration can become large enough to form ferrous hydroxide. The relative structure of ferrous carbonate and ferrous hydroxide and their

reactive properties with dissolved oxygen are beyond the scope of this paper.

Summary

1. There is need for fresh-water corrosion research.
2. The experiments described demonstrate the behavior of solutions at corrosion cell electrodes.
3. Basic data have been obtained to which other data can be related in order to provide an organized approach to the water corrosion problem. Natural waters contain a corrosion inhibitor, varying in concentration or proportion from one supply to another. Without basic data on the primary, partial, or total inhibition of this natural ingredient, there is no hope of correlating the observations made on the effectiveness of other inhibitors or methods of treatment against corrosion.
4. A possible explanation has been provided for the inhibitory effect of bicarbonate and carbonate alkalinity.

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Topic of the Month

Contamination of Nitric Acid As a Source of Error In the Huey Boiling Nitric Acid Test

By ROBERT J. BENDURE*

THE HUEY 65 percent boiling nitric acid test has been used with good success as a measure of the quality of stainless steels of the austenitic type, especially with regard to the effectiveness of the heat treatments employed. Excellent reproducibility between duplicates is obtained, except in those cases where the penetration rates are quite high. Where intergranular attack is severe, the rates between duplicates for individual periods may vary somewhat.

For most types of material the rate of attack follows a similar pattern. The first period rate may sometimes be slightly higher than the second period rate, following which each of the succeeding three periods will have rates as high or higher than the preceding period.

This test has been used in the Armco Research Laboratories for a number of years, the testing being carried out in a laboratory in which chemical analyses are also undertaken. While making Huey tests, rates were obtained which did not follow the pattern outlined above. Very high penetration rates would be obtained for one period, followed by normal rates for the following period. Where high rates were encountered the agreement between duplicate specimens was very poor. Repeating the test might or might not result in high and erratic penetration rates. It also was noted that when high rates were obtained, the test specimens invariably were white and etched whereas duplicates with normal rates were generally brown and unetched.

The heating apparatus used consisted of two multiple burner gas-fired hot plates placed side by side so that twenty-four 1000 ml wide mouth Erlenmeyer flasks could be under test simultaneously. Each flask was equipped with a finger-type condenser, the cooling water being taken from a manifold type distributor.

After eliminating all other possible variations in

the test procedure, the cause of the high and erratic rates was finally isolated. It was found that, on occasion, solutions of hydrofluoric and sulfuric acids were being evaporated to dryness under one of the hot plates upon which Huey tests were being made. These operations were being carried out by analysts other than those making the Huey tests. To determine whether this was the source of the difficulty, Huey tests were conducted while evaporating a mixture of hydrofluoric and sulfuric acids beneath the hot plate. At the same time a high humidity was maintained within the hood by boiling a large container of water. High rates were obtained on all specimens. Subsequent periods in the absence of sulfuric and hydrofluoric acid fumes yielded normal rates. Qualitative examination of the nitric acid solution that had yielded high rates showed the presence of an appreciable quantity of fluorides. Sulfates were not detected.

The cause of the high rates, therefore, was contamination of the nitric acid with fluorides. When the humidity is high considerable moisture condenses on the tops of the finger-type condensers. Fluorides apparently also condensed on the tops of the condensers and drained into the flasks.

The white etched appearance of the affected samples was caused by the action of the resulting nitric-acid-fluoride mixture. Removal of this source of contamination completely eliminated the high and erratic rates.

A somewhat similar situation has been reported by a plant laboratory. It was found that erratic rates encountered in the Huey boiling nitric acid test were eliminated when the use of hydrogen sulfide was discontinued in an area adjacent to the test flasks.

Where other operations are being carried out in the same laboratory in which the Huey boiling nitric acid tests are being made, care must be taken to avoid contamination of the acid from external sources.

* Chemist, Research Laboratories, Armco Steel Corporation, Middletown, Ohio.



NACE News

Ffield Talks to 145 About Ship Corrosion

Paul Ffield, Bethlehem Steel Corporation, Bethlehem, Pa., spoke on A Shipbuilder Looks at Corrosion before 100 members and 45 guests at the January 20 meeting of Metropolitan New York Section. Mr. Ffield recounted the various types of ship corrosion problems experienced and the methods of solving them. His illustrated talk centered on hull and propeller corrosion, emphasizing the importance of "built-in" cathodic protection and the elimination of potential sources of velocity corrosion.

New officers for the section were installed at the meeting. They are: M. Bermann, Brooklyn Union Gas Co., Brooklyn, N. Y., chairman; F. J. LeFebvre, Electro Rust-Proofing Corp., Newark, N. J., vice-chairman and R. H. Lucke, Esso Standard Oil Co., Linden, N. J., secretary-treasurer.

Next section meeting is scheduled for Wednesday, April 28.

Wicen Named to Head North Central Region

North Central Regional Division has announced the results of the election for 1954 officers. Elected were: R. E. Wicen, Chain Belt Company of Milwaukee, chairman; W. A. Deringer, A. O. Smith Corporation, vice-chairman; H. F. Haase, secretary-treasurer. All are of Milwaukee. W. R. Cavanagh, Parker Rust Proof Company, Detroit, is director representing the North Central Regional Division.

Watertown, N. Y. Section Is Under Consideration

Kempton H. Roll, chairman of the NACE Northeast Regional Division has announced that formation of a Watertown (N. Y.) local section is under consideration. John J. Richter, Delrac Corporation, Watertown, New York, is one principally interested in forming the new group.

Constructive discussions on technical material published in Corrosion is welcomed.

Payment of 1954 Membership Dues

In order to avoid interrupted mail and missed copies of CORROSION all NACE members who have not done so already are urged to remit their 1954 MEMBERSHIP DUES before March 31. Association by-laws require that the names of those whose dues are not received by March 31 be dropped from the membership mailing list.

Aluminium Laboratories, Ltd. Researcher To Receive NACE 1954 Junior Award



P. M. AZIZ

Mengel Elected to Head Schenectady-Albany

The recently formed Schenectady-Albany-Troy Section of the NACE Northeast Regional Division has announced the names of officers to serve for 1954. Named were: A. C. Mengel, American Locomotive Co., Schenectady, chairman; E. L. Simons, General Electric Co., Schenectady, vice-chairman; G. S. Cook, General Electric Co., Schenectady, secretary-treasurer. Committee chairmen named were: D. Stewart, chairman of the membership committee and J. A. Baker, chairman of the publicity committee. Both are affiliated with General Electric Company in Schenectady.

Next meeting of the section is scheduled March 23. Trafford W. Bigger, General Electric Co., Schenectady, will speak on Corrosion Problems in Large Turbines.

The 12-issue subscription price of Corrosion to non-members of NACE is now \$9. The single copy price to non-members is \$1.

P. M. Aziz, Aluminium Laboratories, Ltd., Kingston, Ont., has been selected to receive the 1954 Junior Award of the National Association of Corrosion Engineers. The award, consisting of a gratuity of \$50 and an appropriate written acknowledgment, is given annually to the author under 35 years of age whose technical article in Corrosion is considered to be the most meritorious published during the year.

Mr. Aziz's article "Views on the Mechanism of Pitting Corrosion of Aluminum" appeared in the February, 1954 issue of Corrosion and dealt with his studies on the subject. His article was compared with more than 20 other eligible papers.

The award will be made at the 1954 annual banquet of the National Association of Corrosion Engineers at Hotel Muehlebach, Kansas City during the association's Tenth Annual Conference and Exhibition. Norman Hackerman, University of Texas, chairman of the committee which determined the best papers, will make the award.

Mr. Aziz, who has worked since 1949 on studies dealing with the mechanism of aluminum corrosion, spent a year at the Institute for the Study of Metals, University of Chicago, where he carried on research in the fundamentals of corrosion. He holds a B.A. Sc. in chemical engineering and M.A. and Ph.D. degrees in physical chemistry from University of Toronto.

Galvanizing Movie Is Seen at Pittsburgh

The fourth of the 1953-1954 meetings of Pittsburgh Section was held at Mellon Institute Thursday, January 7. The program started with dinner at the Royal York Apartments. Following the dinner a motion picture, "Must Stop Rust," was shown through the courtesy of the American Hot Dip Galvanizing Association. Finally Frank L. LaQue, International Nickel Company, Inc., New York, N. Y., presented an instructive and entertaining talk on protective coatings and corrosion.

The meeting set an all time record for attendance for the Pittsburgh Section with 91 members and guests present.

Tulsa Short Course

Sessions on a "how and why to do it" basis featured the Fifth Annual Short Course on Corrosion of Tulsa Section held February 17-19 at the Mayor Hotel, Tulsa. The course was designed for pipe line foremen, superintendents, field engineers and inspectors.



E. A. Tice, International Nickel Co., Inc., is shown addressing Chicago Section at a dinner meeting January 20.

E. A. Tice Is Speaker At Chicago Meeting

E. A. Tice, with the Corrosion Engineering Section of The International Nickel Co., Inc., New York spoke to 73 persons at a January 20 dinner meeting of Chicago Section. His subject was Preserving What You Have—From the Corrosion Engineer's Viewpoint.

He developed three major themes on the corrosion failure of industrial equipment. They were: 1. Aeration effects which result from both lack of and excess of oxygen. Possible solutions of corrosion arising from this cause were enumerated. 2. Temperature effects. A number of practical means of preventing localized damage from hot spots were given. 3. Velocity effects. Means of increasing or decreasing velocity or agitating a fluid were illustrated. Charts on corrosion rates were presented and case histories were related underlining practical solutions.

San Diego Section Hears Pipe Coating Discussion

M. J. Edwards, San Diego Gas and Electric Company, San Diego, California, spoke on Pipe Coatings at the January 27 meeting of the San Diego Section. Twenty-three members and guests joined in a lively discussion following the talk.

The 1954 officers of the San Diego Section were installed at the meeting as follows: Donald P. Armbruster, San Diego Gas and Electric Co., San Diego, chairman; Dallas G. Raasch, La Mesa, Lemon Grove, Spring Valley Irrigation District, La Mesa, vice-chairman; Otto L. Hepner, City of San Diego, secretary-treasurer.

Articles on corrosion science and technology are welcomed for review by the NACE Editorial Review Committee as material for publication in CORROSION's technical section.

Additional copies of CORROSION are available at 50¢ each to NACE members and \$1 each to non-members.

Orson J. Britton Elected Genesee Valley Chairman

One of the recently approved new local sections in the North East Region has named officers for 1954. Elected officers of the new Genesee Valley Section were Orson J. Britton, The Pfaunder Company, Rochester, New York, chairman; John A. Temmerman, City Chemist, Rochester, vice-chairman; and Nelson B. Carter, Eastman Kodak Co., Rochester, secretary-treasurer.

Mr. Britton, chairman, was instrumental in organizing the section.

First regular meeting of the newly formed Genesee Valley Section was held January 26 in the Rochester German Club. After dinner, a brief business

meeting was conducted at which plans for the future were discussed. The aims and purposes of the section were outlined and plans made to hold two more meetings this spring. An opportunity was then provided for discussion of corrosion problems.

A panel consisting of O. J. Britton of the Pfaunder Company, G. L. Cox of International Nickel Co., N. J. Finsterwalder of Taylor Instrument Company and N. B. Carter of Eastman Kodak Co., presented and discussed typical corrosion problems which they had encountered personally. A general discussion followed with such enthusiasm that the meeting could be adjourned only with the understanding that a similar discussion could be continued at the next meeting scheduled during March.



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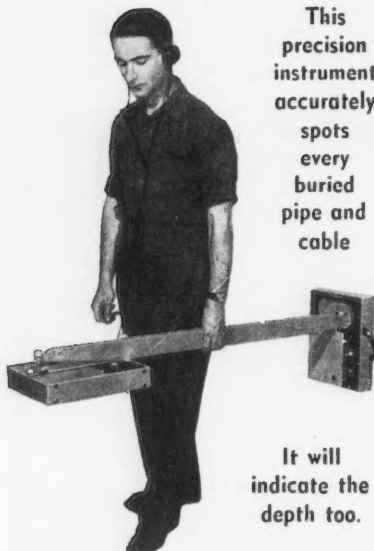
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ODESSA COLLEGE LOAN FUND—Shown here is the ceremony of the presentation of a check for the Odessa College Loan Fund sponsored by Permian Basin Section NACE. Left to right are: John A. Knox, The Western Company, Midland, chairman Permian Basin Section; John C. Watts, Humble Pipe Line Company, Midland, first vice-chairman; E. O. Kemper, Permian Enterprises, outgoing first vice chairman; Bob Warden, Shell Oil Company, Odessa, second vice-chairman; Mr. Fly, president of Odessa College; Thomas M. Newell, Cardinal Chemical Company, Odessa, section trustee; W. A. Hopwood, Tnemec Co., Inc., Odessa, outgoing second vice-chairman.

Snow Does Not Deter Attendance at Meeting

87 Sabine-Neches Section Members and Guests Hear Hackerman on Inhibitors

Norman Hackerman, chairman of the Department of Chemistry, Texas University, Austin addressed 87 members and guests of Sabine-Neches Section at its January 28 meeting. Dr. Hackerman spoke on Corrosion Inhibition.

The meeting was the section's first "Bosses' Night" meeting and was well attended by management personnel from throughout the Sabine-Neches area. In addition to talking on Corrosion Inhibition for the benefit of the visitors, Dr. Hackerman gave a brief history of NACE, its aims and accomplishments.

Speaking on corrosion inhibition for mitigating corrosion he described a corrosion system in terms of its chemistry and then explained how an inhibitor must function to be effective. He discussed how chemicals can inhibit corrosion reactions and gave examples of these mechanisms from laboratory work. He also cited practical examples of good inhibition and of detrimental effects.

Kanawha Valley Hears Fabrication Discussion

At the January 15 meeting of the Kanawha Valley Section 38 members and guests heard W. J. Hegerty, Colonial Iron Works, Cleveland, Ohio, speak on Fabrication Procedures Affecting Corrosion Resistant Process Equipment.

Officers for 1954 were elected at the meeting as follows: George F. Orr, United Fuel Gas Company, Charleston, W. Va., chairman; J. M. Bates, Carbide and Carbon Chemicals Corp., South Charleston, W. Va., vice-chairman; George W. Klorer, E. I. du Pont de Nemours & Co., Belle, W. Va., secretary; Conrad L. Wieggers, Allied Services, Inc., Charleston, W. Va., treasurer.

Mr. Orr, chairman of the 1953 Membership Committee for the section reported an increase of ten members since the last meeting. Next meeting of the Kanawha Valley Section will be March 11 at Charleston, W. Va.

The recently formed Schenectady-Albany-Troy Section of the North East Region held its first 1954 meeting at Union College, Schenectady, New York January 12. Twenty-one members and guests braved 15 inches of snow to attend.

The technical portion of the meeting consisted of three talks: Dr. E. L. Simons, General Electric Co., Research Laboratory, Schenectady, described Fuel Corrosion Problems as Related to Land Gas Turbines. He said corrosion from low cost fuel must be overcome before land gas turbines can replace Diesel electric power. His talk was illustrated with slides and actual samples from gas turbines that demonstrated the nature and cause of corrosion.

R. J. Hayner, Hall Laboratories, Schenectady, discussed corrosion problems encountered in steam boiler operation. He described the role of various inhibitors as well as causes of the possible steam boiler corrosion.

George E. Best, Mutual Chemical Co. of America, presented a round-up on the use of inhibitors for metal protection. Mr. Best also described the aims and activities of NACE to the members of the new section. Mr. Best, past chairman of the North East Region, will take office on the NACE Board of Directors at the March Conference and Exhibition as Director representing the North East Region. He succeeds L. B. Donovan, Consolidated Edison Company of New York.

Officers of the section include A. C. Mengel, American Locomotive Co., Schenectady, chairman; and George S. Cook, Chemical Materials Dept., General Electric Co., Schenectady, secretary.

John V. Kelley

John V. Kelley, chief chemist for The Texas Pipe Line Company, Houston, died January 25. Mr. Kelley had done extensive research work on inhibitors and corrosion by sour crude oil. He also was active in testing coatings against exterior environments.



NACE MEETINGS CALENDAR

- Mar.**
- 8—Cleveland Section.
 - 8—St. Louis Section. Sol Gleser, Corps of Engineers, York Hotel.
 - 9—Houston Section. Corrosion by Fresh Water. C. P. Dillon.
 - 30—Southwestern Ohio Section. Stress Corrosion by W. F. Beck, Talk illustrated by motion picture.
 - 30—Central Oklahoma Section. YWCA, Oklahoma City.
 - No date—Chicago Section.

- April**
- 12—St. Louis Section. Howard D. Segool, Plastic Tapes as Corrosion Control Coatings. York Hotel.
 - 13—Houston Section.
 - 15—Detroit Section.
 - 16 or 20—Cleveland Section. Allerton Hotel. F. L. LaQue, The International Nickel Co., Inc., speaker.
 - 20—Chicago Section. Dr. G. Gutzeit, "The Kanigen Process."
 - 27—Central Oklahoma Section. YWCA, Oklahoma City.
 - 27—Southwestern Ohio. Plant tour, Hilton-Davis Chemical Company, dinner meeting and discussion of tour.

Liebman Speaks on Weld Seam Corrosion Control

A. J. Liebman, vice president and technical director of Pitmar Centrifugal Machine Corp., Baltimore, Md. spoke January 21 to 116 members and guests at a joint meeting of St. Louis Section NACE and the American Welding Society's St. Louis group. His topic was "Weld Seam Corrosion and Its Control." The meeting was held during the evening at the Engineers' Club of St. Louis.

Mr. Liebman explained how corrosion damage will occur on metal adjacent to welds because of splatter, flux slag, fume deposits, weld heat oxide and other factors.

Programs for three scheduled meetings were also announced as follows:

March 8—Sol Gleser, Upper Mississippi Valley Div., Corps of Engineers, U. S. Army, will be speaker at the York Hotel.

April 12—Howard D. Segool, Polyken Products Dept., The Kendall Co., will speak on Plastic Tapes as Corrosion Control Coatings at the York Hotel.

May 10—E. D. Weisert, Haynes Steel Co., will speak on High Alloy Corrosion Resistant Materials at the York Hotel.

Corrosion in Petroleum Industry Morton's Theme

Petroleum industry corrosion problems were discussed by B. B. Morton, International Nickel Co., Inc., New York, N. Y., at the January 12 meeting

of Permian Basin Section. Twenty-three members and 31 guests kept Mr. Morton on the rostrum for over one and one-half hours discussing some moot corrosion problems of the petroleum industry.

Some of the problems discussed were: Is there a danger of cracking the casing of an oil well when an effort is being made to protect oil well casing by means of impressed current?

Can selective sulfide attack take place under the condition of temperature where carbide precipitation can take place in Type 304 stainless steel?

To what extent will corrosion inhibitors serve as a substitute for alloy content in sucker rods or any steel subjected to corrosion fatigue conditions in service?

Does hydrogen sulfide in an oil well

fluid act as an inhibitor or as a corrodent?

Distinguished guests at the meeting were H. D. Murray, Hanley Company, Midland, Texas, R. J. Rice, International Nickel Company, Inc., Houston, and Sam Hodgdon, Metal Goods Corporation, Dallas.

Names of 1954 officers were announced at the meeting. Elected were John A. Knox, The Western Company, Midland, Texas, chairman; John C. Watts, Humble Pipeline Company, Midland, first vice-chairman; Bob Warden, Shell Oil Company, Odessa, Texas, second vice-chairman; Jay Stafford, National Tank Company, Midland, secretary-treasurer and T. M. Newell, Cardinal Chemical Company, Odessa, section trustee on the South Central Regional Board of Trustees.

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HOT DOPE

Straight from the Kettle on PIPE PROTECTION

By Boyd Mayes

• The year 1954, according to most prognosticators (WOW! how'd I ever spell that one?), is going to be the biggest construction year in the history of pipelining. Sounds mighty rosy to us folks out here in the coating, wrapping and reconditioning business. Sure hope those prognos—what-ever-you-call-'em know what they're forecasting around. There's little we'd rather do than get in on the job of helping pipeliners make a better job of all this work. We've been doing it for 26 years now, and our enlarged plant loaded with skilled manpower is ready for business, whatever the size.

We've always been one of those strange critters who believes that optimistic talk makes for good business and that good business is the backbone of the country. We can remember back when some of our 26 years had some kinks in them; also some twists . . . but all you got to do is look to see that the folks who had faith in hard work and in *doing one job well* sure survived.

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CLEVELAND SECTION members and guests who participated in a television program January 10 over station WNBK, Cleveland: Oliver Henderson, George Zetzer, Miss Jane Rigo, William W. Palmquist and Robert C. Weast.

Cleveland NACE Section Gives TV Program

Paint Systems for Severe Corrosion Are Discussed

Sixty-five members and guests attended the January 14 meeting of the Detroit Section. Guest speaker was Kenneth Tator, Kenneth Tator Associates, Coraopolis, Pennsylvania. Mr. Tator spoke on Corrosion Engineering with Protective Coatings. The subject was restricted to a discussion of those paints which are used for industrial applications under severe corrosive exposure. Mr. Tator explained his own unique paint classification system and briefly discussed deviations from standard laboratory test methods which he feels better correlate field experiences. The slide-illustrated talk covered recent developments and economic aspects of coatings.

Vice-chairman of the section, Eugene Ivanso, presided at the meeting. Section Chairman James F. Hirshfeld was ill and could not attend.

Next meeting of the Detroit Section is planned February 25 at the Engineering Society of Detroit Building, with Dr. H. H. Uhlig, Massachusetts Institute of Technology scheduled to present a talk on Corrosion as an Electrochemical process.

McIntyre Talks to Teche Section February 17

Louis F. McIntire, professor of chemical engineering at Southwestern Louisiana Institute, Lafayette, and an alumnus of Ohio State University where he gained his master's and doctor of philosophy degrees under Mars G. Fontana, was scheduled to address members of Teche Section February 17. His topic was Forms of Corrosion and Methods of Retarding or Preventing Their Progress.

The program included also a discussion of local corrosion problems.

Requests for reprints of technical or other material published in CORROSION should be addressed to NACE's Central Office, 1061 M & M Bldg., Houston 2, Texas.

Cleveland Section of the National Association of Corrosion Engineers sponsored a television program devoted to corrosion engineering over station WNBK on January 10. The half-hour program was one of a series presented weekly by Cleveland technical organizations titled "Adventures in Engineering" and designed to interest high school students in engineering as a profession.

Robert G. Weast, associate professor in charge of the Case Institute corrosion laboratory showed a Cleveland Heights high school student, George Zetzer how corrosion is recognized as an electrochemical phenomenon, demonstrating the passage of electricity from corroding objects. He also showed corroded hot water heater sections. Miss Jane Rigo, secretary of Cleveland Section, and in charge of corrosion work at the American Steel and Wire Division of the United States Steel Corp. showed how corrosion can be controlled through proper selection of metals, stressing the need to use corrosion resistant materials for certain parts of automobiles.

Oliver Henderson, electrical engineer with the Ohio Bell Telephone Company explained the methods used by utilities in protecting buried pipes and cables. William W. Palmquist, chemical engineer with National Carbon Company and chairman of Cleveland Section discussed the control of corrosion through use of non-metallic materials and told of current application of these materials in several environments.

ASM Beryllium Papers

Among the papers scheduled for presentation at the American Society for Metals Beryllium Conference March 4-5 at the Statler Hotel, Boston were the following:

Corrosion of Beryllium by M. C. Udy, Knolls Atomic Power Laboratory, General Electric Co., Schenectady, N. Y.

Effect of Grain Size on High Temperature Fatigue Properties by J. E. Breen and J. R. Lane, Naval Research Laboratory, Washington, D. C.

Central Arizona Group Will Ask for Charter

Recognition as the Central Arizona Section will be asked of Western Region NACE by a group of 19 members and others interested in corrosion living in the vicinity of Phoenix, Arizona. A meeting was held at the Arizona Club, Phoenix on February 11 at which formation of the section was discussed and temporary officers elected.

Frank I. Buck, Arizona Public Service Company, Phoenix was named temporary chairman and Carl T. Eyring, Salt River Valley Water Users' Association, temporary secretary.

Next meeting of the section, March 18, will feature showing of the Inco motion picture "Corrosion in Action," under A. G. Zima of Inco's Los Angeles office.

Jacksonville Section Has Four Guest Speakers

Four speakers addressed the January 15 meeting of the Jacksonville Florida Section at Roosevelt Hotel, Jacksonville. Speakers and topics at the meeting were Howard D. Segool, Polyken Products, Kendall Company, Chicago, who spoke on Plastic Tapes as Corrosion Control Coatings; R. V. Pennington and T. T. Collins, National Container Corporation, Jacksonville, who spoke on Experiences in Corrosion Control in Plp & Paper Mills and A. I. Liebman, Pitmar Corporation, Pittsburgh, Pa., who spoke on Corrosion Control Through Economic Surface Preparation. Mr. Liebman used many slides illustrating how surfaces properly prepared give years longer life between repaintings than surfaces improperly prepared.

Haydon Burn, mayor of Jacksonville, was the dinner speaker on his experiences viewing atomic bomb explosions.

There were present 24 members and four guests.

Baltimore Hears Humble On Magnesium Anodes

Hilary A. Humble, Dow Chemical Co., Midland Michigan, guest speaker at the January 12 meeting of the Baltimore Section gave what was considered by those present one of the most enlightening talks of the year. Mr. Humble spoke on uses of magnesium anodes in cathodic protection, illustrating on slides, on a microscopic scale how local corrosion cells operate. He explained that the rate of corrosion depends on the controlling mechanism which may be anodic, cathodic or mixed.

Following a brief discussion on the relative merits of galvanic versus impressed current anodes, Mr. Humble stressed correct design and placement of anodes for proper current distribution.

One interesting feature of the talk was a description of rust prevention in galvanized and glass lined steel hot water tanks. He pointed out that while the tanks were protected from corrosion, cathodic protection resulted in severe corrosion of the copper sheathing around the heating unit which was insulated from the tank proper. He said

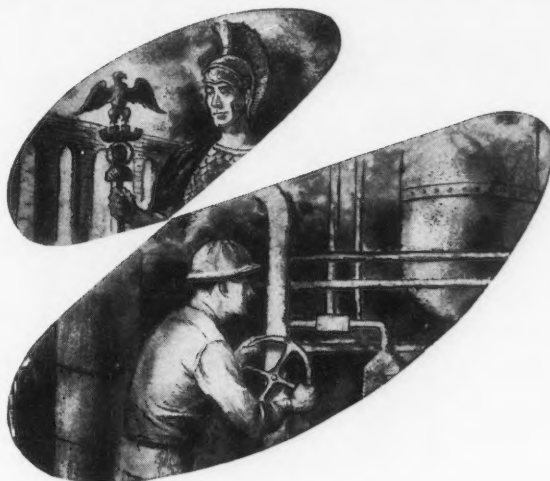
that investigation revealed the cause to be stray currents and that mitigation was achieved by inserting a resistance bond which provided sufficient current drainage to prevent perforation of the copper sheathing.

Mr. Humble also described different types of magnesium anodes, including magnesium ribbon, which can be laid out parallel to pipelines, anodes for underwater hulls of ships and a variety of anodes for industrial purposes such as gate valves and condensers.

In the business portion of the meeting Chairman L. G. von Lossberg asked for nominations for officers for the 1954 meeting season. Nominated and subsequently elected were Dr. A. L. Alexander, chairman and Adolph Bialecki, secretary-treasurer. Dr. Alexander cur-

rently is head of the protective coatings branch of the Naval Research Laboratory in Washington, D. C. Mr. Bialecki is associated with the research laboratories of the U. S. Industrial Chemical Company in Baltimore. Since Mr. Risque L. Benedict, currently secretary-treasurer was unable to accept the nomination for vice-chairman because of recently accepting a job with Creole Petroleum Company in Venezuela it was decided to elect the new vice-chairman at the next meeting.

Articles on corrosion and technology are welcomed for review by the NACE Editorial Review Committee as material for publication in CORROSION's technical section.



LEAD... Why and Where you should use it

Lead was probably the first corrosion-resistant construction material. The ancient Romans were among the first to recognize its value and they used it in the extensive water systems which were a part of their civilization.

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Keeling, Lombardo Are Western Region Meeting Speakers

Harry J. Keeling, consulting engineer and Miss Flora Lombardo, Amercoat Corp. were speakers at the January 13 meeting held jointly by NACE's Western Region and Los Angeles Section at Los Angeles.

Mr. Keeling spoke on corrosion circuit theory. His talk was adapted from a lecture he originally delivered at the 1953 Short Course on Cathodic Protection at the University of California at Los Angeles.

Starting with the basic elements of a

simple corrosion cell comprising two points on a metal surface contacting water solution and using lantern slide illustrations of analogous electric circuit diagrams, Mr. Keeling traced the development of the more complex corrosion circuits found in the usual cathodic protection systems. He explained the importance of such factors as the metallic and non-metallic portions of typical circuits, the extent of the circuit, effect of anode and cathode resistance, fixture resistance etc. He followed this by a detailed analysis of the cathodic protection circuit and its effect on the corrosion circuit, with explanations of: Distribution of resistance, current flow, power increments due to dissimilar metal contacts, shorted insulators or holidays in pipeline coatings and how a real pipeline circuit differs from the



PHILADELPHIA SECTION OFFICIALS—Taken at the December 11 Christmas party of Philadelphia Section. Left to right, S. F. Spencer, Keystone Shipping Company, Philadelphia, secretary-treasurer; E. G. Brink, American Viscose Corp., Marcus Hook, Pa., past chairman; E. G. Holmberg, Alloy Steel Products Co., Linden, N. J., speaker for technical session; H. H. Bennett, Socony-Vacuum Oil Co., Paulsboro, N. J., chairman and J. S. Pettibone, American Society for Testing Materials, Philadelphia, vice-chairman.

basic simple circuit. At the conclusion of his talk Mr. Keeling demonstrated corrosion cell and cathodic protection currents in action using electric lamps and batteries with a working model of a pipeline.

Miss Lombardo spoke on Development of Organic Coatings for Resistance to Marine Corrosion. She described and illustrated with slides certain types of coatings, showing their effects on steel test panels in gelatin electrolyte with a pH indicator in the electrolyte. She showed that certain coatings could cause a reversal of polarity of the natural corrosion cell areas. Her talk was followed by a spirited question and answer session.

Officers for the 1954 season for Western Region were installed at the meeting. They are: Robert H. Kerr, Southern California Gas Co., Los Angeles, chairman; Dean E. Stephan, Chicago Bridge & Iron Co., Los Angeles, vice-chairman; R. E. Hall, Union Oil Co. Brea, Cal., secretary-treasurer.

Los Angeles Section nominated officers for 1954 as follows: for chairman, S. K. Gally, Pasadena; for vice-chairman, E. H. Tandy, Standard Oil Co. of California, El Segundo; for secretary-treasurer, J. R. Brown, Kobe, Inc., Huntington Park.

Molybdenum Produced By Electrolytic Process

Electrolytic reduction of molybdenum from solutions of potassium hexachloromolybdate in molten mixtures of alkali halides is possible with a process developed by Dr. Seymour Senderoff and Abner Brenner of the National Bureau of Standards. Deposits ranging from fine powders to thick coherent layers can be produced by varying the conditions of electrolysis.

It is contemplated that shapes of pure molybdenum may be formed by electrolytic deposition by the method and that a substantial reduction in the cost and difficulty of producing molybdenum will be the result of extensive use of the process.

Corrosion Research

Non-profit research services offered by the Department of Metallurgy of Southwest Research Institute, 8500 Culebra Road, San Antonio 6, Texas include many in the corrosion of metals. The institute offers aid in setting up and reviewing research programs in all fields of metallurgy.



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API Corrosion Papers

Technical papers to be given during the May 10-13, Mid-Year Meeting of the Division of Refining of the American Petroleum Institute include the following. The meeting will be held at the Rice Hotel, Houston.

A Hydrogen Sulfide Analyzer-Recorder. By E. B. Offutt and L. V. Sorg, Standard Oil Company (Indiana), Whiting, Ind.

Corrosion Session—May 10, Morning
Presiding, L. W. Robbie, Republic Oil Refining Co., Texas City.

Corrosion and Prevention—Heat Exchangers in Cooling Water Service. J. D. Munro, Standard Oil Development Co., Linden, N. J.

Selection of Paints and Application in Combating Atmospheric Corrosion. F. T. Radtke, Shell Oil Co., Wood River, Ill.

Hydrogen Chloride Evolution from Crude Oils as a Function of Salt Concentration. G. J. Samuelson, Petrolite Corp., St. Louis.

Waste Disposal—May 12, Morning
Status Report on Research Program of the Smoke and Fumes Committee. Vance N. Jenkins, Union Oil Co. of Cal., Los Angeles.

Gray to Make Address

Dr. Allen G. Gray, technical editor of Steel Magazine, is expected to speak to members of the American Hot Dip Galvanizers Association, Inc. on corrosion problems at Cincinnati March 25-26. The association will hold its annual meeting then at the Netherland Plaza Hotel, during which annual reports will be heard. It will elect three directors to its board and conduct other business.

Boston Section Hears Bake's Address on Neoprene Coatings

Fifty-four members and guests of Greater Boston Section heard Lou Bake, E. I. du Pont de Nemours & Co., Inc., speak on Neoprene Maintenance Coatings. The meeting was held February 3.

Mr. Bake summarized briefly the 25-year history of natural rubber coatings as tank linings and the characteristics which long prevented their development as maintenance coatings; namely, difficult and costly application, low resistance to sunlight and oxidation and lack of a satisfactory method of room-temperature curing. He said that the development, first, of Neoprene in 1931 and later of a specific polymer designated Type KNR permitted use of the material as a brush-applied tank lining although the need for heat curing still delayed its utilization as a maintenance coating. Development of an accelerator capable of vulcanizing the film at atmospheric temperatures brought about the use of Neoprene as a two-part coating system in which the accelerator is added at time of mixing.

Because Neoprene in itself has no specific adhesion to metals or other rigid materials, this system is usually applied in two coats over a chlorinated rubber primer.

While Neoprene compositions, Mr.

Bake said, can be produced in color at some sacrifice of corrosion and abrasion resistance, it is felt that carbon black as a filler delivers maximum protection. He said that two variations of the two-part Neoprene system are recommended, one containing equal parts of carbon black and Neoprene for general tank lining and protective coating use and the other, for maintenance coatings only, containing double the amount of carbon black for increased chemical resistance.

Mr. Bake added that further development work with Neoprene has produced also the so-called "one-shot" coating, a phenolic-resin-modified material requiring no primer. Mr. Bake concluded his talk with the presentation of slides

showing laboratory and field performance of Neoprene boht in tank lining and maintenance, coating service.

John Swift, section chairman, announced with regret the resignation of Vice-Chairman A. Orman Fisher of Monsanto Chemical Company, who shortly will transfer his section membership to the Greater St. Louis Section. Mr. Swift expressed the Greater Boston Section's appreciation to Mr. Fisher for his outstanding contributions to the section's activities and progress.

Next meeting of the Greater Boston Section is scheduled May 5 when the topic for discussion will be Cathodic Protection. The speaker for the meeting will be A. R. Corlett of Harco Corporation.

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NORTHEAST REGION OFFICIALS—Gathered here at a recent meeting are the following officials of the National Association of Corrosion Engineers' Northeast Region and sections in the region (clockwise from lower left hand corner) George E. Best, Mutual Chemical Company of America, Baltimore, regional director elect; M. Bermann, Brooklyn Union Gas Company, Brooklyn, chairman of Metropolitan New York Section; Kempton H. Roll, Lead Industries Association, New York, chairman of Northeast Region; E. J. Tittsworth, Koppers Company, Inc., Boston, secretary-treasurer of Northeast Region; L. B. Donovan, Consolidated Edison Co. of New York, New York, retiring director; Frederick R. Meyer, Southern New England Telephone Co., New Haven, Conn.; past chairman Southern New England Section; J. Dwight Bird, The Dampney Company, Boston, secretary-treasurer of Greater Boston Section and H. E. Bennett, Socony-Vacuum Oil Co., Inc., Paulsboro, N. J., chairman of Philadelphia Section.

First Canadian Regional Meeting Features Technical Papers, Manufacturers' Exhibition

First annual meeting of Canadian Region NACE was held at the King Edward Hotel, Toronto on February 12 with 53 members and 76 non-members present. An exhibition of products designed to aid in corrosion mitigation also was held. Three technical papers were presented during the day.

The program began at 2 pm with registration and inspection of the exhibition. Then followed a paper "Experience in Corrosion Control of a Products Pipe Line," by A. R. Murdison, Pipe Line Division, Imperial Oil Ltd., Toronto. The paper "Considerations of Designated Selection of Materials to Avoid Corrosion," was presented by R. J. Law, The International Nickel Co., Ltd., Toronto.

A fellowship hour between 5:30 and 7 pm was provided by exhibitors.

Following dinner, A. H. Carr, Manager, Koppers Products (Canada), Ltd., commended the efforts of R. J. Law, G. I. Russell, Trans Mountain Pipe Line Co., Vancouver and T. R. B. Watson, Corrosion Service, Ltd., Toronto in arranging the meeting.

G. I. Russell then outlined briefly the history of the National Association of Corrosion Engineers and explained that in Canada less than a year ago the then 87 NACE members in the Dominion unanimously decided to form a Canadian Regional Division of the association. Since this aim was realized membership in Canada has increased to 250 with five sections organized at Toronto, Hamilton-Niagara, Vancouver, Montreal and Edmonton. A sixth is being formed at Winnipeg.

Tentative plans for the 1955 second annual meeting of the Canadian Regional Division call for two or three day session and a probable attendance of 300 to 400, Mr. Russell reported. Larger facilities for exhibitors also are contemplated.

Non-members present were urged to join NACE and take advantage of the large volume of technical information it is creating and assembling.

At 9:15 pm H. P. Godard, Aluminium Laboratories, Ltd., Kingston, presented an illustrated paper "The Corrosion Behavior of Aluminum Alloys."

Articles on corrosion science and technology are welcomed for review by the NACE Editorial Review Committee as material for publication in CORROSION's technical section.

POSITIONS WANTED and AVAILABLE

- Active and Junior NACE members may run without charge two consecutive advertisements annually under this heading, not over 35 words set in 8 point text type.
- Firms seeking employees, regardless of NACE membership, may run an advertisement of the same specifications indefinitely.
- Advertisements to other specifications will be charged for at standard rates.

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60 Participate in Round Table Session Of Pittsburgh Section

Sixty members and guests attended the round table discussion on corrosion of special metals and alloys at the February 4 meeting of the Pittsburgh Section. A selected group of experts engaged in technical sales of metals and alloys comprised the panel. They were: J. J. Hager, United States Steel Corporation; Edward W. Hopper, Crucible Steel Company; R. A. Woofter, Jones & Laughlin Steel Corp.; H. W. Fritts, Aluminum Company of America; W. G. Renshaw, Allegheny Ludlum Steel Corp.; John S. B. Rutherford, Babcock & Wilcox Co.; H. B. Bomberger, Jr., Rem-Cru Titanium, Inc. Moderator was Robert F. Mears, United States Steel Corporation. Many of the participants said they believed they had received considerable aid toward solving their corrosion mitigation problems.

Frank Costanzo, chairman, paid special tribute to Thomas T. Royston, who passed away in Knoxville, Tennessee on January 21. Mr. Royston was secretary of the Pittsburgh Section during 1953. L. G. Royston was appointed to serve as secretary for the remainder of the term.

The next meeting scheduled by the Pittsburgh Section is March 4. The section scheduled a tour of the Aluminum Company of America Research Center, New Kensington, Pennsylvania. Following the tour, a paper prepared by D. O. Sprowls, C. J. Walton and J. D. Nock, Jr., all of Alcoa, entitled "Resistance of Aluminum and Other Metals to Atmospheric Corrosion" is programmed.

Thomas T. Royston

Thomas T. Royston, for 13 years vice-president and treasurer of Royston Laboratories, Inc., Blawnox, Pa., died suddenly January 21 at Knoxville, Tennessee while on a business trip. A life-long resident of Pittsburgh, Mr. Royston was for 30 years, before joining Royston Laboratories, Inc., affiliated with Crucible Steel Company. He served as secretary of the Pittsburgh Section of NACE during 1953 and has been active in NACE since he became a member in 1949. At the time of his death he was 67.

Nickel Savings by Using HF Grade Alloy Possible

By using an HF grade alloy for castings destined for service in the temperature range 1200-1600 degrees F, substantial savings of nickel can be made. This conclusion was reached by A. M. Hall, Chief of the Division of Alloy development at Battelle Memorial Institute, Columbus, Ohio. The discovery was made as a result of research at Battelle sponsored by the Alloy Casting Institute during the past 30 months. The recommended alloy contains approximately 20 percent chromium and 9 percent nickel as compared to the 26 percent chromium and 12 percent nickel of the previous used HH grade.

The research indicates the mechanical properties of the alloy are comparable to those of higher-nickel heat resistant alloys.

Trends toward higher operating temperatures in some industries, notably power plants, are pushing the low alloy materials now used for furnace construction to their limits of usefulness. The availability of the cast HF alloy usable at temperatures above these limits will permit engineers to take advantage of the efficiency of higher-temperature operation.

Investigating a broad series of experimental alloys, the Battelle group found that the most useful range is as follows: 19 to 23 percent chromium, 9 to 12 percent nickel and 0.25 to 0.40 percent carbon. This composition has been designated as the HF alloy type. In general, the mechanical properties of the austenitic HF compositions in the 1200 to 1600 F range are comparable to those of the higher-nickel alloys. At 1400 F,

the 100-hour rupture stress (an indication of load-carrying ability of the metal at high temperatures) of a typical HF composition is about 14,000 psi. This is the same as the representative value for the higher-nickel HH grade.

After service at high temperatures, the residual room temperature mechanical properties of an alloy are important. For example, some materials become quite embrittled and thus difficult to handle in maintenance or repair operations. The HF grade, as-cast, has satisfactory ductility as shown by an average elongation value of about 30 percent. After 24 hours' exposure at 1400 F, the elongation is approximately 17 percent—still adequately ductile. Comparative figures for the higher-nickel HH grade are only: 20 percent as-cast and 10 percent after 24 hours at 1400 F. Thus, the HF grade not only conserves nickel, but actually provides a material of superior ductility for intermediate temperature service.

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Many Cathodic Protection Problems Discussed

A Panel on New Phases of Cathodic Protection, a coffee speaker and barbecued chicken all received close attention from Section members attending the February 9 meeting held at Kelley's dining room.

Members of the panel presented questions for discussion. Lyle R. Sheppard, Shell Pipe Line Corp., presented cases where cathodic protection has not been entirely effective. He listed the following examples. 1. Leaks have been reported by three companies within 200 feet of the drainage points on rectifier protected pipe lines. Yet at greater distances away from the drainage points

protection was effective. 2. Leaks have been reported by two companies on well coated lines under cathodic protection of well over 850 mv soil-to-pipe potentials. 3. Several companies have reported leaks on bare or poorly coated lines under apparently adequate cathodic protection in dry alkaline soils. 4. One company has questioned the effectiveness of cathodic protection on lines buried above the frost line in the soil. 5. One company has had difficulty in cathodically protecting near reinforced concrete foundations. It is investigating the effects of such protection on the foundations. 6. Several companies have experienced dif-

ficulties in applying cathodic protection to line sections in lower resistance soils isolated by high resistance strata, yet effective protection is maintained from the same power source on the line beyond this section.

Measurements to Make

Mr. Sheppard said the following measurements need investigation: 1. Pipe to soil potentials on well coated lines protected by galvanic anodes. 2. Pipe to soil potentials in high resistant soils. 3. Soil resistances in high resistant soils. 4. Pipe line coating resistance. 5. Natural earth currents. 6. Insulation of flanges. 7. Current flow between parallel lines, including rectifying effects of iron oxides. 8. Testing of networks.

As for probable future developments needing investigation, he listed: 1. Corrosion effects of fertilizers and soil conditioners. 2. Use of electrical check valves. 3. Corrosion and protection by alternating current. 4. Problems created by use of pre-stressed steel pipe. 5. Use of germanium rectifiers. 6. Directional beaming of cathodic protection. 7. "Water break-down" voltages. 8. Buried rectifier power lines. 9. Utilization of soil resistance for distribution of cathodic protection. 10. Protection design for expanding systems. 11. Standardization of terms, practices and methods.

Louie Barbe, Humble Pipe Line Co., listed some methods of minimizing interference drainage: 1. Proper location of drainage points. 2. Keeping current density as low as possible. 3. Installation of bonds on crossing lines. 4. Use of auxiliary drainage.

A corrosion engineer often must consider damage his cathodic protection system will inflict on other companies' installations in the vicinity. Some problems, Mr. Barbe cited were: 1. Maintenance of adequate records on crossing lines. 2. Securing cooperation with owners of other lines. 3. Dealing with small firms which have no corrosion engineer. 4. Legal liability for damage to other installations done by cathodic protection. Other technical problems dealing with interference are: 1. Standardized procedure for making interference measurements. 2. Minimum distance for crossing lines. 3. Complete mathematical solution of interference problems. 4. Coating of foreign lines at crossings. 5. Interference with operation of railway signal systems.

Big Pipe Problems Listed

A. L. Stegner, Tennessee Gas Transmission Co., presented the following questions regarding large diameter pipe lines: 1. Why does large pipe require more current per square foot than small pipe? 2. Why is the pipe-to-soil potential necessary for protection different for large pipe than for small diameter pipe? 3. What is the best way to get sufficient current in high resistant soils?

Starr Thayer, consulting engineer and pioneer corrosion expert spoke briefly in a humorous vein, describing some of the radical methods pioneer engineers tried when corrosion control had very little resemblance to a science. Speculating on the future, Mr. Thayer, who received the 1952 Frank Newman Speller Award, said engineers may find a way

(Continued on Page 14)

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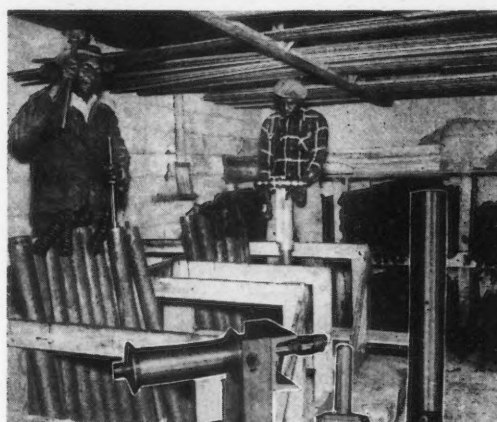
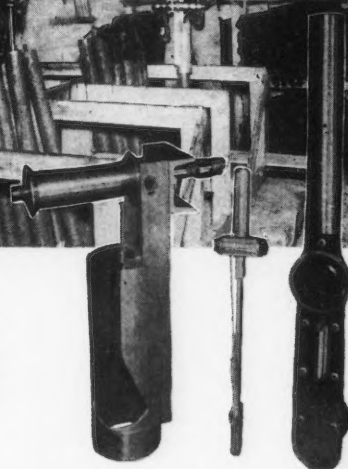


Photo above shows testing of CPS graphite anodes for permanency of lead-wire attachment. At right (A) "Torkflash" testing device developed by CPS to assure quality control of lead-wire attachment. (B) Non-destructive minimum 300 lb. setting wrench (C) Indicating destructive tester.



*See "Graphite Electrodes"—Industrial and Engineering Chemistry—Jan. 1954 p. 2.

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Corrosion on Electrified Railroads Is Southern New England Topic

Experiences of 40 years in dealing with corrosion problems on railroads used by both electric and steam locomotives were related to members of Southern New England Section at its February 3 meeting. Harry F. Brown, consulting engineer, formerly with the New York, New Haven and Hartford Railroad told the meeting of the extended tests and numerous types of materials for overhead structures on electrified railroads.

After Mr. Brown's talk a two-part motion picture of the United States Navy's educational series on "Inductance" was shown.

The meeting was held in the auditorium of the United Illuminating Co., New Haven.

F. W. Meyer, Southern New England Telephone Company, turned the gavel of office over to the section's new chairman, A. W. Tracy, American Brass Company. Mr. Tracy gave the following names of committee chairmen:

Fred Barry, Chase Brass Co., meetings and program; J. Simmons, Whitehead Metal Products, membership; F. W. Meyer, publicity; H. Johnquest, The Bristol Co., reception; A. M. Plant, United Illuminating Co., social; Prof. R. W. Robertson, Yale University, technical conference. Mr. Meyer also was named alternate delegate to regional board meetings.

Next meeting of the section will be in April at Connecticut Light and Power Company's Berlin, Conn. plant when members and guests will see testing facilities of the company's engineering department.

Panel Discussion Held By Southwestern Ohio Section January 26

Southwestern Ohio Section met January 26 in Cincinnati, Ohio. Twenty-three members and guests enjoyed the technical meeting, which consisted of a well balanced and interesting panel discussion followed by a question and answer period. R. J. Novak, Dayton Power and Light Company, spoke on power plant problems. Al Jenss, Ampco Metals, Inc., spoke on alloys; Roy O. McDuffie, University of Cincinnati, spoke on metals, and Sylvan Falck, Inner-Tank Lining Corporation, spoke on protective coatings.

Seven More Exhibitors Added for Kansas City

Seven more exhibitors have been assigned space in the exhibition to be held in connection with the NACE Tenth Annual Conference at Kansas City March 15-19. They are: Cleaner Pipelines Company, The Colonial Plastics Manufacturing Co., Midwest Research Institute, St. Louis Metallizing Company, Standard Magnesium Corp., Permolite, Inc. and Tube Kote, Inc.

This brings to 96 the number of companies scheduled to exhibit.

Hydrogen Absorption Under Stress Seems To Be Sulfide Stress Corrosion Culprit

Hydrogen absorption under stress appears to be the most significant factor in the sulfide stress corrosion failure of iron-nickel alloys. This conclusion was reached by Prof. William D. Robertson, whose investigations in the Hammond Metallurgical Laboratory at Yale University are being sponsored by the

Technical Practices Committee Is Named

Composition of the NACE Technical Practices Committee has been set. This group, consisting of a chairman, vice-chairman, the NACE vice-president, and the chairmen of each of the technical committees will exercise a policy making function principally, as determined by the revised rules of procedure effective with the last day of the Kansas City Conference.

Composition of the committee has been given as follows by the chairman: H. W. Schmidt, The Dow Chemical Company, Midland, Mich., chairman.

C. P. Larrabee, U. S. Steel Corp., Vandergrift, Pa., vice-chairman.

F. L. Whitney, Jr., Monsanto Chemical Company, St. Louis, NACE vice-president.

E. C. Greco, United Gas Corp., Shreveport, La., chairman of T-1 on Oil and Gas Production.

W. H. Stewart, Sun Pipe Line Company, Beaumont, Texas, chairman of T-2 on Pipe Lines.

F. M. Watkins, Sinclair Research Lab., Harvey, Ill., chairman of T-3 General.

F. E. Kulman, Consolidated Edison Co. of New York, chairman, T-4 Utilities.

P. J. Gegner, Columbia-Southern Chemical Co., Barborton, Ohio, T-5 Process Industries.

A. J. Liebman, Pitmar Centrifugal Machine Co., Pittsburgh, chairman T-6 Protective Coatings.

High Purity Hot Water Committee Authorized

Organization of a technical committee tentatively titled "Corrosion by High Purity Water at Elevated Temperatures," has been authorized by H. W. Schmidt, chairman of the NACE Technical Practices Committee. D. J. dePaul, Westinghouse Electric Corp., Pittsburgh is preparing to hold a meeting of persons interested in this subject during the Tenth Annual Conference at Kansas City in March.

It is probable the committee will be located under T-3 General in the new organization schedule.

Engineering Building

Construction of a \$1,378,000 downtown Engineering Center is planned by the Cleveland Engineering Society. It will be designed to be the focal point for engineering activities in Northeastern Ohio and will replace present society headquarters at 2136 East 19th St. The new structure will be erected on the site of the present Drake Hotel, which will be demolished.

National Association of Corrosion Engineers' Technical Practices Sub-Committee I-G on Sulfide Stress Corrosion. The research program, financed by contributions from industries interested in the phenomenon of sudden failure of tubing in oil wells producing gas of high sulfide content, has been underway since July, 1951.

Further research contemplated by Professor Robertson will be to determine the susceptibility associated with the combination of mechanical properties and hydrogen absorption under stress of various materials and structures. Different environments may be used to isolate the role of sulfide compared to other hydrogen producing media.

Several other significant conclusions have been established tentatively so far in the program. Among the most important of these are that failure is not necessarily associated with the presence of martensite as had been postulated in the first stages of the research and that minor impurities are not a primary factor in cracking susceptibility.

Initial aims in the research included a determination of the effect of cathodic charging of hydrogen and a comparison with hydrogen absorption from hydrogen sulfide to separate the effects of hydrogen embrittlement from corrosion cracking. It was learned early that there was no difference in effect on unalloyed iron between hydrogen sulfide and cathodically charged hydrogen. Furthermore it was indicated that loss of ductility resulted from hydrogen embrittlement rather than from corrosion cracking. This led to the conclusion that ductility might be a better mechanical criterion than hardness. Earlier research elsewhere had pointed to a specific hardness factor as a dividing line between susceptibility to sulfide stress corrosion cracking and insusceptibility. It now appears that the hardness criterion serves to indicate a limiting inherent ductility below which the embrittling effect of hydrogen will cause failure under stress.

Apparatus is being prepared with which Professor Robertson plans to investigate the hydrogen absorption characteristics of various materials and structures and to relate hydrogen content to mechanical properties, particularly fracture stress.

Numerous Cathodic-

(Continued from Page 12)
to use small atomic batteries for cathodic protection.

In a brief business meeting, members discussed by-laws for the section. Vote on approval of the by-laws will be by mail ballot. Travel facilities for members attending the Annual NACE Conference in Kansas City, Mo., March 15-19 were announced. Addition of a special NACE Houston Section car and a lounge car was proposed by one railroad, provided sufficient interest is shown.

"Corrosion by Fresh Water" by C. Paul Dillon, Union Carbide and Carbon Co., will be the technical subject for the Houston Section March 9 meeting. Mr. Dillon is chairman of NACE Technical Practices Subcommittee 8A, Corrosion by Gulf Coast Cooling Waters.

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Navy Expects 90 to 1 Savings Ratio From Cathodic Protection Installations

By DONALD G. JENKS*

SAVINGS in maintenance costs which may run as high as \$40 million during the next 10 years are expected to accrue to the nation as a direct result of an aggressive program for cathodic protection at more than 100 Naval shore installations. The Navy's Bureau of Yards and Docks is responsible for the construction, operation and maintenance of service utilities for all of the activities comprising the Naval Shore Establishment.

Investigations of corrosion damage and corrosion problems have been made during the past three years at about 30 major fleet activities, including shipyards, operating bases and naval stations; at about 25 naval air stations, about 20 supply and fuel depots and about 15 ordnance plants and depots as well as at more than a dozen other miscellaneous but equally important defense installations.

Many different kinds of structures have come under the eyes of the corrosion engineers responsible for the accomplishment of the current program. These structures represent more than \$50 million worth of utility service distribution and operation equipment, of which perhaps \$10 million is in fuel tanks and piping, \$5 million in water tanks and piping, \$10 million in underground lead-sheathed power and communication cables and \$3 million in gas piping. In addition to these structures, there are many millions invested in miscellaneous structures such as waterfront piers and bulkheads where facilities are required for docking and repairing vessels of the fleet.

Replacement Is Deferred

The greater portion of the anticipated savings will accrue through elimination or postponement of urgent need for replacement of structures which would be destroyed without cathodic protection. The cost of protection is ridiculously low in view of the expected return, being of the order of only about \$100 thousand a year as against approximately \$5 million a year previously required for maintenance and replacement.

Only by the concerted efforts and co-operation of a great number of naval officers and civilian engineers has the navy's program to overcome corrosion by cathodic protection been put into operation, so that, for the next 10 years it will continue to pay off at the rate of approximately \$5 million a year in actual reduction of operating expenses.

It is self evident that credit for attaining this highly desirable and commendable objective must be spread throughout the group of people whose farsightedness has assisted in the implementation of the navy's cathodic protection program. The savings will be real and not merely paper profit and will be made possible by elimination of need for thousands of man-hours of labor and tons of expensive material

which otherwise would be necessary for repairing leaks, digging up and replacing pipe lines and repairing and replacing miles of underground power and telephone cables.

Savings Ratio Is \$90 to \$1

The cost of installing and operating cathodic protection at the 100 or more locations at which work has been authorized is expected to be only about 5% percent of conservatively estimated replacement cost which was foreseen without cathodic protection. Put another way, the navy will benefit at the rate of about \$90 for each dollar expended now for cathodic protection and will be realized over the next ten years of operation. That represents a return of about \$9 for each dollar invested per year for 10 years to come.

The bureau's cathodic protection program has moved forward cautiously because the navy must necessarily be conservative in its expenditure of the taxpayer's dollars. A policy has been established and pursued whereby, if the cost of cathodic protection exceeds more than 15 to 20 percent of annual replacement (amortization) cost, engineers are hesitant to authorize cathodic protection unless it is certain that the usefulness of the installation will be required for that 10-year base period for which cathodic protection would be designed.

Cathodic protection is not a new thing to the navy nor the Bureau of Yards and Docks. Certain structures for which this bureau is responsible have been under cathodic protection for more than 16 years. Only recently, however, have the economies of early installations proved themselves. Now that the savings are certain, a general policy of corrosion mitigation by cathodic protection has been adopted wherever it can be shown to be technically feasible and economically justified. As a result, no effort will be spared to take full advantage of the potential savings involved, in order that the financial burdens of maintenance may be reduced as much and as soon as possible.

It was no simple problem for the bureau to start the ball rolling for a program of this nature. The naval establishment on shore is a huge organization, with boundaries which are being pushed out still further year by year. In order to implement and accelerate the program, corrosion engineers from private industry, highly qualified in the field of cathodic protection, were called in to assist in getting the program off to a flying start. In this way it was possible to take action in many locations simultaneously. Each of the firms co-operating in the program sent teams of trained corrosion engineers into the field, dividing assignments at the more than 100 locations involved and made electrical resistivity measurements, metal-to-soil and metal-to-water potential measurements, made visual inspections and chemical analyses. Also they applied experimental techniques involving the forcing of hundreds of amperes of electrical current through the earth to determine the degree of corrosion damage taking place and the characteristics of a cathodic protection system

which would halt this damaging corrosion for a long time to come.

Naval Personnel Helped in Work

At each activity visited by these engineering survey teams, they were assisted locally by naval personnel, both uniformed and civilian. These professional teams were very generous when it came to divulging their trade secrets in order that naval personnel might attain as great an understanding and as high degree of instruction as possible concerning the application of cathodic protection.

As fast as preliminary investigations were completed at each location, designers and draftsmen went to work to grind out plans and specifications to provide the necessary cathodic protection. Such work was accomplished both in the Bureau of Yards and Docks and in the offices of the professional corrosion engineers. As soon as plans were ready, regular construction contracts were awarded, either in the bureau or by bureau-controlled field activities, leading to required installations. In this way potential savings began to accrue almost at once and have been increasing month by month ever since as additional cathodic protection systems are put into operation. These systems will continue to provide protection for 10 years to come with only minor supervision and maintenance.

Cathodic protection is an electrolytic process which actually reverses the galvanic and electrolytic current flow which is so harmful to metallic structures unless it is properly controlled. An improperly designed or installed and operated cathodic protection system can do irreparable damage to an underground structure. For this reason, only properly trained and qualified engineers are authorized to put newly installed cathodic protection systems into operation. Periodic testing is necessary for efficient and safe operation, but, if properly handled, will pay off at the approximately 20-1 ratio that makes this technique so attractive to engineers in industry and in the navy.

In addition to elimination of damage to structures already installed, the bureau revised its design criteria to provide for cathodic protection of new installations wherever such was found to be justified at time of installation.

Navy, bureau and private industry's engineers have cooperated magnificently in the solution of many new technical problems which have been met in the course of the work to date. Each cathodic protection system is an individual problem and each presents a new and different challenge to the corrosion engineer. In many cases there were no precedents and completely original solutions were required. In some cases recourse was made to pilot-installations on a relatively small scale, with authorization for a complete system deferred until the pilot installation had proved itself both feasible and economical. As a result, the bureau has at hand possible solutions for numerous types of structures concerning which little or nothing previously had been designed, insofar as cathodic protection was concerned.

Other Organizations Interested

The activity of the bureau in this field of work attracted considerable at-

(Continued on Page 30)

* Electrical Engineer, Engineering and Technical Services Division, Navy Dept., Bureau of Yards and Docks, Washington, D. C.

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Permian Basin Section Hears Featherly Talk on Magnesium Anodes

R. L. Featherly, Dow Chemical Company, Midland, Michigan, gave a talk on Applications of Magnesium Anodes before 50 members and guests at a Permian Basin Section meeting February 8 at Odessa, Texas. Mr. Featherly's talk was well received.

Permian Basin Section has as an objective a drive designed to double membership and has issued a challenge to any other NACE local section to do the same.

Next meeting of Permian Basin Section is set for March 8. The speaker on

the program is B. G. Iverson, district engineer for Kewanee Oil Company. The subject of his talk is "Sub-Surface Corrosion Control in the McElroy Field."

General Electric Reports Corrosion Control Gains

Among the developments reported by General Electric Company, Schenectady are the following:

A butyl-molded 5 kv transformer for outdoor service was developed. The corrosion resistant structure has mounting features permitting top, side or bottom connections.

A new welder was perfected for joining stainless steel without the use of flux.

An electrode for welding stainless-steel turbine components operating at 1100 degrees F was developed. Its composition is such that the ferrite content of deposited weld is within 1 to 4 percent; the silicon carbon limited to 5 to 1 ratio.

Chrome carbide investigations indicate the material ultimately may be used for jet turbine buckets. New developments give greater wear resistance with correspondingly less corrosion and erosion resistance or the converse. Chrome carbide is being used as balls for valves at temperatures between 1100 and 1500 degrees F.

Control over potential corrosion problems derived from systematic study of dissimilar metal joint systems has opened the way for the application of aluminum magnet wire in many types of electrical apparatus.

Ceramic Materials Is Houston Meeting Topic

Several papers of corrosion interest are scheduled to be presented April 2 during the Fifth Houston Engineering Symposium at the auditorium of the Prudential Building, 1100 Holcombe Blvd., Houston. The symposium is sponsored by the 22 technical groups comprising the Engineers' Council of Houston of which the National Association of Corrosion Engineers' Houston Section is one.

The papers include: Properties, Manufacture and Use of Porcelain-Enamelled Iron by J. J. Canfield, Armco Steel Corp., Middletown, Ohio.

Modern Developments in Porcelain-Enamelled and Ceramic Coatings by W. N. Harrison, National Bureau of Standards, Washington, D. C.

Manhattan College Sets Instrumentation Session

A one-day Conference on Instrumentation in Water, Sewage and Industrial Waste Treatment will be held at Manhattan College, 242nd St. and Broadway, New York 71, N. Y. on April 22 from 9 am to 5 pm. The college's Civil Engineering Department sponsored a similar event last year.

It is designed to bring together makers and users of instruments for water purification and waste treatment. Technical papers will be presented, proceedings will be distributed to registrants and additional copies may be secured for a nominal sum.

New British Magazine

The Institution of Mechanical Engineers, London, has issued the first number of the first volume of "The Chartered Mechanical Engineer," a periodical which will be the journal of the institution. It will be issued monthly except during July and August.

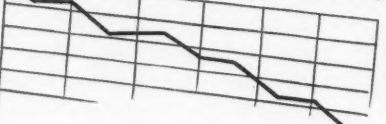
A foreword in the first issue says: "... the Council ... believe that it will be the means of making available to mechanical engineers valuable information which does not fall strictly within the scope of existing publications."

The summer meeting of the institution will be held in Holland during the week beginning June 14, 1954.

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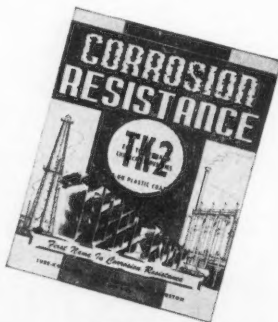
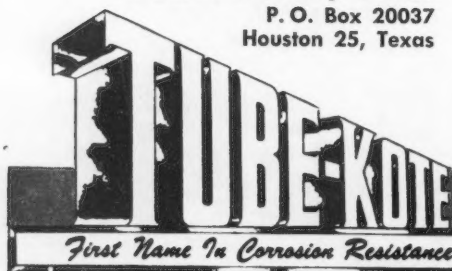
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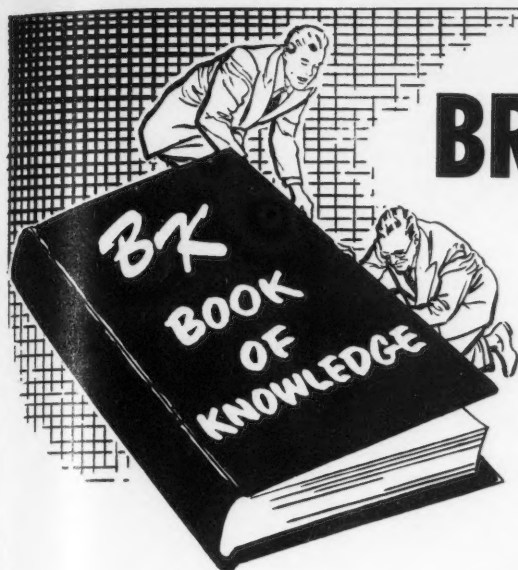
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which tells all about TK-2. It gives case histories, chemical data, and describes method of applying. Or see page 4979 in your Composite Catalog.

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Inter Society Corrosion Committee

**CORROSION MEETINGS
CALENDAR**

Mar.

- 1.5 American Society for Testing Materials, Spring Meeting, Shoreham Hotel, Washington, D. C.
- 2 American Society for Testing Materials, Washington-Oregon Area, joint meeting with AIChE and ASM, Richmond, Washington.
- 4-5 American Gas Association, Transmission and Storage Conference, Jung Hotel, New Orleans, La.
- 4-5 American Society of Metals, Mid-Winter meeting, Hotel Statler, Boston, Massachusetts.
- 15-17 Mid-West Gas Association, Fort Des Moines Hotel, Des Moines, Iowa.
- 17 American Society for Testing Materials—Philadelphia District, joint meeting with ACS, Hotel Dupont, Wilmington, Delaware.
- 15-19 National Association of Corrosion Engineers, Annual Conference and Exhibition, Municipal Auditorium, Kansas City, Missouri.
- 16-18 American Railway Engineering Association, Annual Meeting, Palmer House, Chicago, Illinois.
- 22-24 American Society for Testing Materials, Committee D-20 on Plastics, Hotel Roanoke, Roanoke, West Virginia.
- 25-26 New England Gas Association, Hotel Statler, Boston, Mass.
- 25-26 Oklahoma Utilities Association, Annual Meeting, Biltmore Hotel, Oklahoma City, Okla.

April

- 13 American Society for Testing Materials, New York District, joint meeting with TAPPI, New York, New York.
- 20-23 Indiana Gas Association, Annual Meeting, French Lick Springs Hotel, French Lick, Indiana.
- 20-23 American Gas Association, Distribution, Motor Vehicles and Corrosion Conference, Mount Royal Hotel, Montreal, Canada.
- 26-28 Southern Gas Association, Annual Convention, Houston, Texas.

May

- 2-6 The Engineering Chemical Society, Inc., LaSalle Hotel, Chicago, Illinois.
- 17-18 Society of Naval Architects and Marine Engineers, Spring Meeting, Olympic Hotel, Seattle, Washington.
- 24-26 American Gas Association, Production and Chemical Conference, William Penn Hotel, Pittsburgh, Pa.
- 27-28 Natural Gas and Petroleum Association of Canada, Prince Albert Hotel, Windsor, Ontario, Canada.

June

- 12-25 American Institute of Electrical Engineers, General Summer Meeting, Biltmore Hotel, Los Angeles, Calif.
- 13-18 American Society for Testing Materials, Annual Meeting and Exhibit, Sherman Hotel, Chicago, Ill.
- 20-24 Canadian Gas Association, Banff Springs Hotel, Banff, Alberta, Canada.

- 28-29 Michigan Gas Association, The Grand Hotel, Mackinac Island, Michigan.
- (No Date) National District Heating Association, Annual Meeting.

July

- 11-14 American Society of Refrigerating Engineers, Hotel Olympic, Seattle, Washington.

Sept.

- 8-10 Pacific Coast Gas Association, Victoria, British Columbia.
- 28-29 Texas Mid-Continent Oil and Gas Association, Baker Hotel, Dallas, Texas.
- Sept. 29-Oct. 1 Porcelain Enamel Institute, Annual Meeting, The Greenbriar, White Sulphur Springs, West Virginia.

Oct.

- 3-7 The Electrochemical Society, Fall Meeting, Boston, Mass.
- 11-14 American Gas Association, Annual Convention, Atlantic City, New Jersey.
- 11-15 American Institute of Electrical Engineers, General Fall Meeting, Hotel Morrison, Chicago, Ill.
- 12-15 National Association of Corrosion Engineers, South Central Regional Meeting, Dallas, Texas.

Nov.

- 1-3 American Institute of Mining and Metallurgical Engineers, Institute of Metals Division, Fall Meeting, Sheraton Hotel, Chicago, Ill.
- 1-5 National Metal Exposition, Chicago, Ill.
- 8-11 American Petroleum Institute, Conrad Hilton Hotel, Chicago, Ill.
- 15-18 American Gas Association, Operating Section, Organization Meetings, Hotel New Yorker, New York.

1955

May

- 9-13 A.G.A. Industrial Gas School—(location to be announced).
- 16-18 Southern Gas Association, New Orleans, Louisiana.

June

- 5-9 Canadian Gas Association, Annual Meeting, General Brock Hotel, Niagara Falls, Ontario, Canada.

Oct.

- 17-19 A.G.A. Annual Convention, Los Angeles, California
- 17-21 National Metal Exposition, Detroit, Michigan (A.G.A. will exhibit).

Nov.

- 13-18 The American Society of Mechanical Engineers, Congress & Hilton Hotels, Chicago, Illinois.

1956

Oct.

- 15-16 National Metal Exposition, Philadelphia, Pa. (A.G.A. will exhibit).
- 29 to Nov. 1 A.G.A. Annual Convention, Atlantic City, New Jersey.

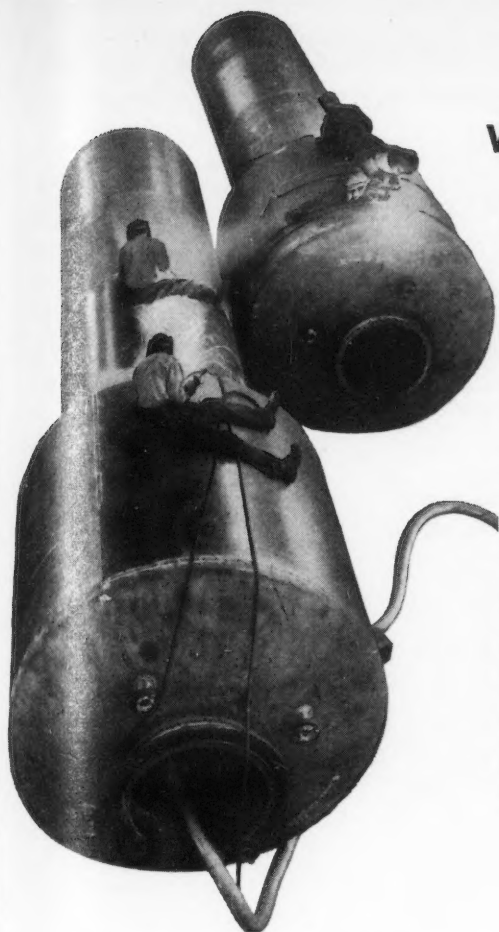
Nov.

- 25-30 The American Society of Mechanical Engineers, Statler Hotel, New York, New York.

1957

Oct.

- 21-25 National Metal Exposition, Cleveland, Ohio (A.G.A. will exhibit).



In Ammonium Sulfate Manufacture Monel is used for mother liquor tanks, scrubbers and in saturators like these being made at the Colonial Iron Works, Cleveland, Ohio. Each of these units is 30 feet high, with a 6 ft. diameter at the bottom, 9 ft. diameter at the top. $\frac{1}{4}$ " Monel plate is used for the shells.

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Treating Coal Distillates: Monel tanks and agitators are used in treating crude benzol, light oils, naphthalene and similar products with sulfuric acid.

Whenever you deal with dilute sulfuric acid there is an excellent chance that Monel is the best and most economical metal to use to safeguard your equipment.

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NEW PRODUCTS — Materials — Service — Literature

Hastelloy C paddles used in a 10 percent 165 to 170 degree pickling bath where severe aeration takes place have outlasted materials previously used 16 times, according to an article in the *Haynes Alloys Digest*, Vol. 5, No. 1, January, 1954. The publication is issued by Haynes Stellite Division of Union Carbide and Carbon Corp., Kokomo, Ind.

Koppers Company will build a new mechanical development laboratory at its South Baltimore plant for 50 personnel to be occupied with refinement and adaptation of present products and processes.

Koppers Co., Inc. has received a contract for engineering services and field assistance in the building and operation of a new styrene polymer plant in France at Mazingarbe. It will have a rated capacity of from 10 to 14 thousand metric tons yearly.

Stauffer Chemical Company has started construction of a \$3,500,000 plant at Louisville, Ky. on the Ohio River. It will use hydrocarbons to produce hydrogen chloride, perchlorethylene and carbon tetrachloride.

A Nickel Alloy Coating can be produced on ferrous surfaces by means of a process developed and patented by New York Testing Laboratories, Inc., 74-80 Washington St., New York 6, N. Y. The process consists of application to the metal surface to be coated a mixture of phosphorus containing salts and nickel oxide and subsequent treating of the coated surface with heat in the range of 1600 degrees F. The laboratories claim that the resulting coating then forms a system which includes a ternary iron-nickel-phosphorus interface between the coating and the basis metal. Vessels too large to be heated in furnaces may be coated similarly and the heat applied locally to reduce the composition.

Vego Chemicals Black, a coal tar derivative, makes a definite bond with metal, penetrates rust and stops the formation of rust, manufacturers, Chemicals and Materials Corp. Terre Haute, Ind. claims. The material also will seal and penetrate masonry, wood, composition, felt and paper roofing materials. Available in four grades of viscosity and coverage, it dries to a flexible film. Resistance to dry heat of Vego Chemical Black No. "O" is claimed to be 750 degrees F. It is distributed by Brance-Kracy, Inc., 4411 Navigation Blvd., Houston, Texas. This firm also is distributor for Kerpro, a VPI aerosol rust inhibitor available in hand-sized cans. The spray is directed at the surface to be protected where the effective chemical is deposited as a thin white film. The length of time the inhibitor will be effective is dependent on air circulation. Technical bulletins on both products are available on request.

Feon polyethylene filter cloth, woven of polyethylene monofilaments is recommended for free-filtering applications

such as coarse crystalline materials or fibrous pulps. It is made by Filtration Fabrics Div., Filtration Engineers, Inc., 155 Oraton St., Newark 4, N. Y.

Light-Weight corrugated aluminum roofing sheet 0.024-inch thick is now available in the same alloys as standard thickness sheets.

Lebanon Steel Foundry, Lebanon, Pa. will send on request its slide chart giving reference data on 19 carbon and low alloy grades and 17 stainless and corrosion resistant grades of steel castings. The chart gives nominal analysis, minimum mechanical properties and heat treatment. Comparable ACI, AISI, ASTM, Hydraulic Institute, SAE, U. S. Military and Federal designations, where applicable, also are given.

Molded Polyester resins manufactured by Bakelite are used by Zenith Plastic Company, 1548 West 135 St., Gardena, Cal. to fabricate tail sections for the Navy's Neptune patrol bombers. Savings in cost of about 80 percent over comparable metal fabrications are claimed, without sacrificing strength, durability or utility.

Type I PVC needle, plug and globe valves in sizes from $\frac{1}{8}$ to 2 inches are now available from Atlas Mineral Products Co., Mertztown, Pa.

Magnetism in Steel Castings, a data sheet issued by Empire Steel Casting, Inc., Reading, Pa. discusses the relative importance of magnetism in chromium and in chrome nickel stainless castings and wrought types.

Agitated Kettles in metals ranging from aluminum to stainless steel and in all pressure ratings based on fixed outside shell diameters in code and non-code construction are described in a new brochure available from The Colonial Iron Works Co., 17643 St. Clair Ave., Cleveland 10, Ohio. Agitation elements include Colonial standard and special turbine, standard propellers, anchors and paddles.

Alwac, a general purpose computer said by Logistics Research, Inc., Redondo Beach, Cal. to equal the work of a million dollar computer at a cost of \$48,000 can calculate, conclude, choose and perform reasoning operations with information and do other thinking. The machine is a serial, binary computer with internally programmed magnetic drum. It features a rotating magnetic drum memory of 2048 word main storage capacity.

Plastic Pipe is now in full production by Youngstown Sheet and Tube Company, Youngstown, Ohio at the Sand Springs, Okla. plant of The Fibercast Corp. in which Youngstown recently acquired an interest. It is centrifugally molded of Bakelite polyesters in a process developed by Perrault Brothers Inc., Tulsa.

How to Control Marine Corrosion with Galvanic Anodes, its Bulletin No. 161

is available from Federated Metals Division, American Smelting & Refining Co., 120 Broadway, New York 5, N. Y.

Making the Most of Spray Painting Method, a 45 minute sound 16 mm film produced by the DeVilbiss Company, Toledo, Ohio illustrates the four basic principles of spray finishing. A booklet is available for distribution with the film. The film is obtainable for showing from the DeVilbiss Company, 300 Phillips Ave., Toledo 1, Ohio.

International Nickel Co., Inc., New York 5, N. Y. has the following reprints available on request: Development and Control of Engineering Gray Cast Irons by R. A. Flinn and D. J. Reese; Corrosion Resisting Characteristics of Iron-Modified 90:10 Cupro Nickel Alloy, by William C. Stewart and F. L. LaQue.

The Science of Making Brass, a 16 mm color documentary 29-minute color film which has been awarded first prize at the International Film Festival Turin, Italy, is available on loan basis from Chase Brass and Copper Co., Waterbury 20, Conn. It shows casting, extrusion, drawing and rolling processes.

Kleer-Stream automatic oil recovery units which remove and store oil from liquids which ordinarily are discharged as sewage are manufactured by Pioneer Pump Division, Detroit Harvester Co., 2750 Guardian Bldg., Detroit 26, Mich. The saved oil and finishing and grinding compounds may be reused, and the residual effluent will have reduced effect in stream and lake pollution. The unit is wholly automatic in operation.

GS Type SO pouring spouts for pouring liquids into small containers are made of acid resisting rubber and plastic tubing. They are available from General Scientific Equipment Co., 1412 Packard Bldg., Philadelphia 2, Pa.

Minneapolis-Honeywell Regulator Company's Elektronik Duplex Function Plotter automatically measures two variable conditions and simultaneously plots their relationship to a third.

New Horizons in Aluminum Brazing, a 22 minute, 16 mm sound film available on loan from Motion Picture Section, 854 Alcoa Building, Pittsburgh 19, Pa. shows the advantages of brazing in the design and fabrication of aluminum products.

Atpet 100, a sorbitan fatty acid ester developed by Atlas Powder Company is reported by manufacturers to be superior to other oil additives in inhibitive power and to have other desirable characteristics. It has an advantage over sulfonate inhibitors in that it leaves no ashy residue in engines, is wholly synthetic and therefore fully controllable. It has no effect on the pour point of some oils and limited effect on some others and is soluble in most oils. Nu-

(Continued on Page 24)

For its North Dakota products line the
Standard Oil Company (Indiana) selected

New Light-weight, reinforced
TRANSHIELD
ASBESTOS PIPE LINE FELT



Stretching a distance of 200 miles from Mandan, N. D. to Moorhead, Minn., the new products pipe line will provide a valuable link connecting the new Mandan refinery with the mid-western products pipe line system of the Standard Oil Company (Indiana).

Permits high speed wrapping...
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On the job shown above, coating and wrapping rates up to 17,000 feet per day were reported. This remarkable record is a tribute to Transshield's special tear-free reinforcement. This reinforcement is accomplished through the use of continuous glass yarns, parallel spaced on $\frac{1}{4}$ " centers.

Designed for average soil conditions, Transshield is a light-weight felt composed of coal-tar saturated asbestos. This time-tested material assures an efficient barrier between pipe line enamels and earth loads . . . soil stresses.

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Long-Length Rolls—Available in 800-ft. rolls (14" O.D., 2" I.D.) for traveling power-driven coating

and wrapping machines. Other lengths can be furnished to suit your method of application. Widths are from 2" to 36".

Johns-Manville has developed three wrapping materials for pipe line protection:

J-M 15-lb. Asbestos Pipe Line Felt (perforated or unperforated)—for severe soil conditions.

J-M Transshield Asbestos Pipe Line Felt—for average soil conditions.

J-M Trantex polyvinyl pressure sensitive tape—for pipe line corrosion protection where ease of application is important such as when coating field joints of mill-wrapped pipe or making emergency pipe line repairs.

For further information write Oil Industry Department Johns-Manville, Box 60, New York 16, N. Y.



Johns-Manville ASBESTOS PIPE LINE FELT

NEW PRODUCTS

(Continued From Page 22)

merous humidity cabinet, static water drop tests, turbine oil rust preventive tests and salt spray cabinet tests indicate it is superior to certain other inhibitors of known performance. It may be used as an additive to diesel fuel and fuel oil and at low concentrations it is effective in preservative engine oils, fuels and pipelines, gear lubricants, film type corrosion inhibitors and slushing compounds.

Fluoroseal, a compound for plastic and metal threads based on duPont's tetrafluorethylene resin, serves as a lubricant and sealer but does not harden, Industrial Plastic Fabricators, Inc., Norwood, Mass. claims.

Klad Kote 356, said to have a 240 degree flash point, is a new fingerprint remover compound developed by R. M. Hollingshead Corp. Camden, N. J. The petroleum base compound is said to be effective for 30 days and to eliminate the interplant slushing oil operation.

Mylar polyester films are used for insulation in a new induction motor developed by Westinghouse Electric Corp., 401 Liberty Ave., Pittsburgh 30, Pa. which also has a molded glass impregnated plastic blower fan for maximum resistance to contaminated atmospheres. The motor, which is totally enclosed, is designed for use in corrosive atmospheres and environments.

Opal-Glo, colored interior wall coatings in which aluminum is a principal ingredient are being manufactured by

Sherwin-Williams Company in seven shades. For industrial use the paints have 50 percent light reflectivity even with the deeper colors, good durability, cleaning ease and high coverage.

Controlled Atmosphere Hoods made of impregnated fiber glass by P. M. Leonard Co., Inc., 671 Bergen St., Brooklyn 17, N. Y. are light weight, portable and can be adapted to control by vacuum or pump dust, bacteria or moisture.

Cathodic Protection of most of the underground piping at Cities Service Refining Corp., Lake Charles Refinery will be installed by Cathodic Protection Service, Houston. The installation, to use between 2500 and 3000 amperes DC from selenium rectifiers through graphite ground rods is believed by CPS to be the largest package cathodic protection installation on record. The company recently completed protecting the refinery's underground lead sheathed cable.

J. C. Nicholson, formerly vice president of Natasco, Tulsa has purchased the interest of J. A. Halpine in Tank Service, Inc., Tulsa, 3319 North Lewis. The company will fabricate, modify, repair and coat tanks.

Homalite CR-39, a clear, transparent, scratch and abrasion resistant sheet material developed from thermosetting resins is rated by the manufacturers as 30 times more scratch and abrasion resistant than most commercially available plastics. Information can be obtained from The Homalite Corp., 14 Brookside Drive, Wilmington 166, Del.

Colonial Tubular Equipment, Catalog T-53 published by The Colonial Iron Works Co., 17643 St. Clair Ave., Cleveland 10, Ohio describes and illustrates the company's standard and custom exchangers, evaporators and crystallizers.

Sperry Ultrasonic Reflectoscopes are described and operated in a 10 minute sound-color educational film available for showings to interested groups from Sperry Products, Inc., Danbury, Conn.

18% Nickel Silver strip, up to six inches wide and down to 0.0005-inch thick with tolerances as close as plus or minus 0.0001-inch is now being rolled to a high finish by American Silver Co., Inc., 36-07 Prince St., Flushing, N. Y. It is available in any quantity from one to thousands of pounds.

Conductivity Tests on floors of operating rooms, personnel and equipment in ordnance and chemical plants, paint factories, refineries and other places where static electricity may be a hazard now can be made according to National Fire Protection Association recommendations with Model 269 Vibrotect. It is described in Bulletin 2B available from Associated Research, Inc., 3750 West Belmont Ave., Chicago 18, Ill.

Rubber is bonded to nylon bearings by injection molding in one operation using a method developed by Minnesota Rubber and Gasket Co., 3630 Wooddale Ave., Minneapolis 16, Minn. Savings in cost up to 50 percent are claimed over older methods.

(Continued on Page 26)

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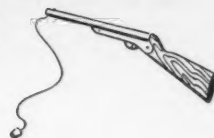
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NEW PRODUCTS

(Continued From Page 24)

Dyestuffs and other chemical products will be manufactured at a plant to be erected on a 150-acre site acquired by Pittsburgh Coke and Chemical Company of Pittsburgh at Spartan, South Carolina. Immediate construction of a modern factory for the company's fine chemicals division is planned.

Patents on Hall Laboratories, Inc. process for the use of metaphosphate in the treatment of water systems to prevent internal corrosion of piping were upheld in a mandate of a United States appeals court. The company had sued a textile mill in South Carolina alleging infringement of its 1943 patent granted to Owen Rice and George B. Hatch of Pittsburgh.

Molded Synthetic rubber casings are now used on a new displacement pump manufactured by Eco Engineering Co., 12 New York Ave., Newark, N. J. The pump, which has the same features as the manufacturer's stainless steel and Teflon pumps is suitable for corrosive fluids with capacities up to 10 gpm and 100 psi for sustained service. Internal parts are available in Type 316 stainless steel or Monel.

Ace-Flex, a general purpose, clear flexible tubing with inside diameters from 0.120 to 1 inch is now being manufactured by American Hard Rubber Co., 93 Worth St., New York 13, N. Y. A bulletin describing the tubing lists about 100 materials and rates the tubing against them as satisfactory, unsatisfac-

tory and test before using. While the material from which the tubing is made is not mentioned the fact it is rated unsatisfactory for use with acetone, aromatic hydrocarbons, Freon, ketones, lacquer thinners and zylol may be indicative.

Lead Plated sheet-steel enclosures for safety switches and circuit breakers are being produced by Trumbull Components Dept., General Electric Co., Plainville, Conn. They are suggested for use in corrosive environments in place of cast iron types formerly used.

Naylor Light-Weight pipe is described in Bulletin No. 507 available from Naylor Pipe Co., 1230 East 92nd St., Chicago 19, Ill. The spiral pipe is available in nominal diameters from 4 through 30 inches. The nominal weight of 20-inch OD plain end pipe is 17.5 pounds per foot.

Porcelain Enameled aluminum for architectural uses is being produced by Ingram-Richardson Manufacturing Co., Beaver Falls, Pa.

Appleton ST Services Connectors permit liquid-tight joining of flexible electrical conduit. Details are available on request from Appleton Electric Co., 1701-59 Wellington Ave., Chicago 13, Ill.

PERSONALS

J. M. Weldon has been made assistant to the vice-president of The International Nickel Co., Inc. and has been transferred to the sales department. **C. J. Bianowicz** has been named manager of the Inco Nickel Alloys Department and **Daniel W. Machon** has been put in charge of the newly established Cobalt Section of the Nickel Sales Department.

James F. McNamara has been elected chairman of the board of Alox Corp., New York following the recent purchase of control of Alox by Surpass Petroleum Ltd., Toronto of which he also is chairman of the board.

D. O. Lachmund has been named vice-president in charge of sales for Amercoat Corp., South Gate, Cal. He formerly was Eastern region salesmanager in charge of the company's New Jersey offices.

S. B. Withington has been named president of the newly consolidated Lycoming Division of Avco Manufacturing Corp.

Ernest Derr has been assigned to customer Service at its Houston plant, **Walter Goethem** to development in the Thermoplastic Structures Division and **Eric Van Anglen** to field service, same division by Atlas Mineral Products Corp., Mertztown, Pa.

Theodore A. Haschke has been named director of sales of the newly-organized industrial chemical division of Stauffer Chemical Company, its subsidiaries and associated companies.

Everett C. Gosnell has been appointed chemical engineer by The Ohio Machine and Boiler Company, 14819 Detroit Ave., Cleveland 7, Ohio. He will serve as consultant specializing in the design and production of corrosion resistant process equipment. He formerly was with Koppers Co., Pittsburgh, The International Nickel Co., Inc., Lukens Steel Company, Colonial Iron Works and the Centrifix Corp. all in capacities related to corrosion control.

W. M. Trigg has been named manager of Westinghouse Electric Corporation's new metals development plant to be built at Blairsville, Pa. **Leonard W. Golden** and **R. D. Rowley** have been named his assistants. The plant will be known officially as the materials pilot manufacturing department.

John A. Faas has been appointed chief mechanical engineer of Walter Kidde Constructors, Inc., New York and Houston.

Robert F. Taylor has been appointed manager of Minnesota Mining and Manufacturing Company's plastic pipe project to develop, produce and prepare for market pipe produced under patents acquired from Gustin-Bacon Manufacturing Co., Kansas City. The companies will cooperate in producing glass fiber reinforced plastic pipe, fittings and couplings.

Robert Von Rotz has been appointed chief engineer of Tuthill Pump Company, Chicago.

Glenn J. Gibson has been appointed to the engineering staff of the Cooper Alloy Foundry Co., Hillside, N. J. He will direct the company's research program aimed at developing superior methods for welding corrosion and heat resistant alloys.

Eugene J. Houdry has been given the John Scott Medal Award by the Board of Directors of City Trusts in the Philadelphia Engineers Club. He received the award in recognition for his development of the catalytic cracking process for petroleum.

Joseph P. Lawlor, president of General Filter Company, Ames, Iowa has been elected mayor of Ames.

John Sulton, Jr. has been named sales manager for Oklahoma and the Texas Panhandle for Nelson Manufacturing Company, Tulsa.

B. C. Mulheran will head the recently established Cleveland sales office of Automotive Rubber Company, Inc., Detroit and Houston.

Charles E. Huddleston, Jr. has been named assistant sales manager of the Southwestern territory of Socony Paint Products Co.

F. G. Merckel has been elected president; **R. M. Jackson** executive vice-president and treasurer and **G. D. Peet**, vice-president in charge of product engineering and development by Wallace & Tiernan Co., Inc., Belleville, N. J. The company was merged with Novadel-Agene Corp. January 1.

(Continued on Page 30)

Lapel Pins



Approx.
Size

Approximately 7/16 inches high, gold, inlaid with bright red enamel background to "NACE" and deep blue enamel background to words "CORROSION CONTROL." Ruby center.

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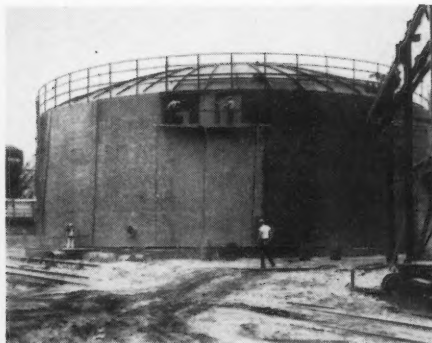
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Origin and Activities of CITCE Are Outlined

By M. POURBAIX* and
P. VAN RYSSELBERGHE*

A. Introduction

AS LONG AS the fundamental bases of a science or technique are not entirely known, an essential element of progress is lacking in that science or technique. Advances are no doubt possible, but they are uncertain and linked to the intuition and ingenuity of a few experimenters whose pioneering work is all the more admirable.

Every experimental science has had as first stage this period of fragmentary discovery filled with astonishments and disappointments before the facts, as well as with controversies concerning the interpretation of those facts. Physics, electricity and chemistry, for instance have each known this "romantic" period. The development of these sciences was laborious and jerky until energetics and mathematics made it possible to establish their essential foundations. From then on the facts were recorded in a quiet order, research lost some of its poetry but gained in logic and considerable progress was accomplished in a relatively short period of time. One became able to understand and to predict.

The phenomena of metallic corrosion are most of the time extremely complex; they pertain to widely different disciplines, among which particular mention should be made of the physics of metals, of the science of interfaces and of the physical chemistry of the three states of matter. One cannot therefore speak of one theory of corrosion, but of several; corrosion theories can be based only upon the fundamentals of very diversified phenomena, about which a considerable amount of research is actively being carried out in numerous countries. In most cases, these researches are still in the exciting but unrewarding stage of intuitive discovery, yet the moment seems close when the joint work of numerous scientists will bring the light needed for systematic progress. In physics, electricity and chemistry it is energetics which has brought most of this light; it is clear that energetics can bring this same light to electrochemistry, and consequently to all phenomena of an electrochemical nature; among these we should mention particularly corrosion, electrolytic phenomena (electrodeposition and refining of metals, electrolytic polishing and other electrolytic reductions and oxidations), catalysis in solution, the functioning of cells and storage batteries, a large number of oxidations and reductions intervening in general and in analytical chemistry. Electrochemical thermodynamics gives to all these phenomena a rigorous and harmonious frame, synthetic and cartesian, whose scientific and technical interest is of the first order and this not only for studies and researches in the fields listed above, but also for the teaching of electrochemistry, to which it can bring very desirable order.

In a recent appeal in favor of fundamental research in electrochemistry, R. M. Burns¹ quoted D. A. MacInnes² statement that: "Processes of living tis-

suess intimately involve electrochemistry" and added: "Contributions to our knowledge of electrode reactions, overvoltage, passivity, oxidation and reduction kinetics, the processes of conductance in structures as diversified as nerve fibers, semi-permeable membranes and solid semi-conductors should have important and unpredictable consequences in broad areas of science, technology and human affairs." The pursuit of systematic studies in electrochemistry could not find a better justification.

The first applications of electrochemical energetics, which may also be called electrochemical thermodynamics, go back to the work of Haber, who in 1898 called attention to the importance of the concept of electrode potential; however, in spite of the success of Nernst's work on the subject, much time elapsed before the value of this concept was fully appreciated. Towards 1935, this concept was simultaneously revived in various countries and its usefulness in corrosion was emphasized by U. R. Evans and his school at Cambridge and by Wagner and Traud at Darmstadt. In 1947 the Faraday Society devoted to it one of its important "Discussions." The possibilities offered by thermodynamics as a study tool in electrochemistry and connected fields are now well recognized, and one witnesses at the present time in this direction an abundance of contributions which enable one to obtain, often very rapidly, results presenting a considerable practical interest.

B. Constitution of the Committee

In 1948, one of us (P. V. R.), who had been studying at Eugene, Oregon, with the collaboration of P. Delahay the use of polarography in corrosion, came to Europe under the auspices of the Office of Naval Research, at which time we had the opportunity of discussing problems of common interest, in electrochemistry and corrosion.

In close collaboration with F. E. C. Scheffer and W. G. Burgers (Delft) and with the help of G. Chaudron (Paris), one of us (M. P.) undertook in 1937, at the University of Brussels, a thermodynamic study of the electrochemical behavior of metals and non-metals, based upon the use of electrochemical equilibrium diagrams (drawn in terms of potential and pH) and of polarization curves. The kinetics of electrodeposition and dissolution reactions of metals was being studied by R. Piontelli at the Milan Politecnico and by J. Heyrovsky at the Charles University in Prague. At the University of Cambridge, U. R. Evans, who may be regarded as the pioneer in the scientific study of the corrosion of metals in presence of aqueous solutions, had put into evidence, with the collaboration of T. P. Hoar, the electrochemical nature of this corrosion and the importance in it of the role of the potential. At the "Ecole Supérieure" of industrial chemistry and physics in Paris, G. Charlot had renovated the teaching of analytical chemistry, particularly by the use of potential-pH diagrams. G. Valensi at the University of Poitiers and J. O. M. Bockris at the Imperial College in London had actively preoccupied themselves with the possibilities of the use of electrochemical thermodynamics.

There was thus, upon common foundations, an important task to accomplish whose amplitude and difficulties were beyond the possibilities of isolated investigators and for whose realization direct contacts between the different interested parties could be particularly fruitful. Most of the chemists and electrochemists mentioned above met with some Belgian scientists on March 28-30, 1949, at the University of Brussels for discussions on electrochemistry and its applications. At the conclusion of this meeting the Committee of Electrochemical Thermodynamics and Kinetics was constituted with the following as "character members":

Belgium: C. Boute, J. Gillis, A. Juliard, M. Pourbaix (Secretary).
Czechoslovakia: J. Heyrovsky.
France: G. Charlot, G. Valensi.
Great Britain: J. O. M. Bockris, T. P. Hoar.
Italy: R. Piontelli.
The Netherlands: W. G. Burgers.
United States: P. Delahay, P. Van Rysseberghe (President).

The object of this committee would be to promote international collaboration in the fields of electrochemical thermodynamics and kinetics and their applications. Its members would carry out active research in these fields and would agree to orient some of their investigations along directions decided upon and occasionally revised at the meetings of the committee. The work of the committee would be done on the basis of the most complete cordiality and frankness and would be, as far as possible exempt from formalism and presided over by friendship.

At the end of the Brussels meeting it was agreed that the starting program of the committee would be as follows:

1. Preparation of an "Atlas of Electrochemical Equilibria."
2. Systematic determination of the polarization curves of electrochemical reactions.
3. Miscellaneous applications:
 - (a) Corrosion.
 - (b) Catalysis in solution.
 - (c) Electrolysis and storage batteries.
 - (d) General chemistry and analytical chemistry.

C. Activity and Development of the Committee

1. Activities.

Meetings: The Committee held a second meeting on September 18-22, 1950, in Italy (Milan and surroundings), a third meeting on August 6-11, 1951, in Switzerland (Bern), a fourth meeting on September 10-13, 1952, in Great Britain (London and Cambridge) and a fifth meeting on July 25-28, 1953, in Sweden (Stockholm). The Belgian section of the Committee held two study sessions on November 9, 1949, and December 3, 1951, respectively. At the time of the first of these reunions, this section was established as a "National Research Center."

Program of Work:

The program of work remained very similar to the initial one but has been slightly widened. At present it is as follows:

(Continued on Page 29)

* University of Brussels, Belgium.

** University of Oregon, Eugene.

Origin And—

(Continued From Page 28)

- a. Electrochemical behavior of metals and non-metals in the presence of aqueous solutions:
Potential-pH diagrams—
"Atlas of electrochemical equilibria" and "Practical diagrams"—
Polarization curves of electrochemical reactions. Electrochemical reversibility and irreversibility.
- b. Applications to the study of corrosion and of protection against corrosion:
Circumstances of corrosion, passivity and passivation.
Action of inorganic inhibitors.
Action of pigments in paints.
- c. Applications to the study and teaching of general chemistry and analytical chemistry.
- d. Applications to the study of electrolytic phenomena:
Cell and storage batteries.
Electrodeposition of metals.
Electrolytic polishing.
- e. Electrochemical nomenclature and definitions.
In general the Committee will occupy itself with all fundamental problems of electrochemistry.

Special Commissions:

In order to facilitate the realization of this program of work the committee has constituted three study commissions whose objectives and present members are listed below (the names of the chairmen are in italics).

- a. Commission on "Potential-pH diagrams": *G. Charlot, P. Delahay, M. Pourbaix, G. Valensi, P. Van Rysselberghe.*

This Commission's present objective is the establishment of an "Atlas of electrochemical equilibria" and of "Practical diagrams" at the temperature of 25 degrees C.

- b. Commission on "Nomenclature and electrochemical definitions": *J. O' M. Bockris, R. Defay, E. Lange, R. Piontelli, G. Valensi, P. Van Rysselberghe.*

This Commission's objective is the study of all questions pertaining to electrochemical nomenclature and definitions.

- c. Commission on "Experimental methods in electrochemistry": *P. Delahay, H. Fischer, U. Franck, R. Gauguin, K. Huber, J. Massart, R. Piontelli, A. Riis.*

This Commission's present objectives are the establishment of a glossary of terms and magnitudes used in experimental electrochemistry and the study of various questions in regard to the realization, classification and critique of experimental methods.

Study Groups:

In order to facilitate further collaboration among those members who are particularly interested in the realization of investigations in certain areas within the frame of its program of work, the committee has recently decided to constitute two study groups to deal with the following subjects:

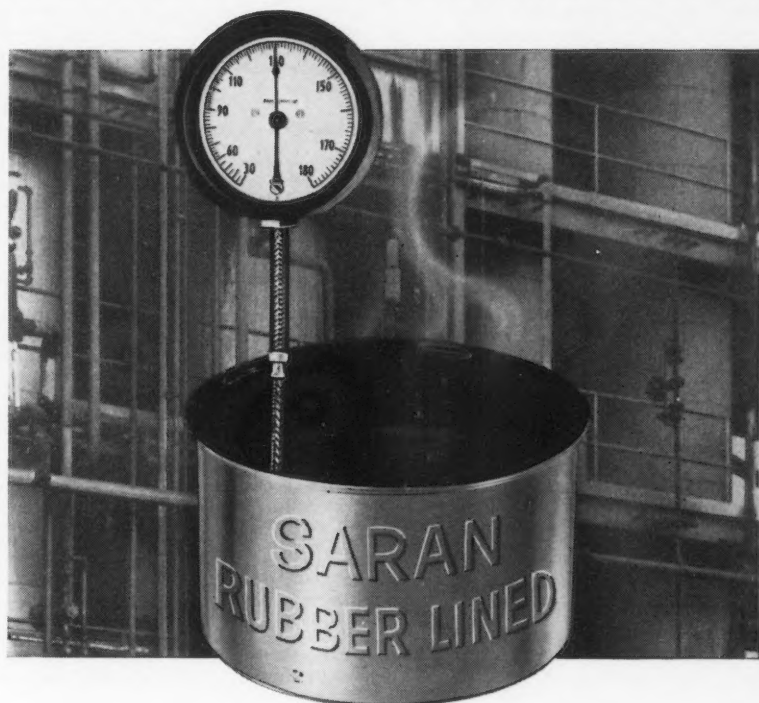
G.1—Corrosion and protection against corrosion.

G.2—Cells and storage batteries.

These study groups differ from the commissions listed above in that they do not pursue a specific program; each member of a group is invited to bring

(Continued on Page 30)

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Saran Rubber Lined Tanks Resist Corrosive Actions of Solutions up to 130°F.

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RELATED PRODUCTS—Saran rubber molded parts—stoppers, diaphragms, various-sized moldings for valves, instruments, etc.

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Norwegians Will Probe Tanker Corrosion Causes

Six months' preliminary research by the Ship Research Institute of Norway into the reasons for and methods of controlling internal corrosion of oil tankers is reported in a brochure issued by the institute and the Central Institute for Industrial Research, Oslo. The investigations indicate cathodic protection and the addition of wetting agents to the cargo and ballast offer best possibilities for successful mitigation.

The studies were initiated after severe pitting had been observed in tankers carrying Near East crude oils.

Other control methods considered were new alloy construction materials, removing dissolved oxygen from ballast water, desalting wash and sea water, controlling cargo tank humidity and using inert gases in vapor space.

Navy Expects—

(Continued From Page 16)

tention from other government organizations. Bureau engineers frequently have acted as consultants and advisers to other groups, assisting in their indoctrination in the sound philosophy of cathodic protection and supplementing knowledge already possessed by these outside engineers.

Although the bureau is primarily concerned only with naval installations made on dry land, certain floating structures are a part of their responsibility and were included in the general work of this program.

The overall program is expected to continue indefinitely, with expansion to the limit of its economic advantage. By such continuation it is hoped that the annual maintenance cost of the naval shore installation will be further reduced as a continuing result. This is advantageous both to the bureau, the navy and to the taxpayers.

PERSONALS

(Continued From Page 26)

L. F. Heverly, recently resigned chief corrosion engineer for Great Lakes Pipe Line Company and formerly associated with Ebasco Services, Inc. for several years has formed his own corrosion consulting engineering firm to be known as Heverly Engineering Company, 5425 Chadwick Rd., Kansas City 3, Kans.

B. M. Downey, manager of Shell Chemical Corporation's Houston plant has been appointed manager of manufacturing and **A. W. Fleer**, manufacturing operations manager has been named manager of research, development and engineering by the corporation.

W. D. Sullivan has been elected a vice-president of The Babcock & Wilcox Company and placed in charge of the manufacturing department of the company's boiler division. **M. Nielsen**, a vice-president of the company has taken charge of the boiler division.

J. C. Hoff has become associated with Kawecki Chemical Co., Boyertown, Pa., as sales representative in Indiana, Michigan, Ohio, Illinois and Wisconsin. His headquarters will be in Detroit.

Dr. G. Karl Vogelsang has been appointed technical director of the Gates Engineering Co., Wilmington, Del. Dr. Vogelsang will lead and coordinate the Gates research and development laboratories with special emphasis on neoprene and vinyl protective coatings.

Appointment of **O. E. Anderson** to its technical staff has been announced by Continental-Diamond Fibre Co. A specialist on materials used in electrical insulation, including laminated plastic products and flexible coated fabrics, Mr. Anderson will be technical service representative for the company's Silicone, Teflon, and Polyester flexible sheet and tape products.

Roy W. Davis has been appointed sales manager of the Paints and Emulsion Dept. of the Philip Carey Mfg. Co., Cincinnati, Ohio. He had been a salesman in the Carey, Cleveland, Ohio district.

C. Paul Hugel has been made vice president and sales manager of Chicago Decorating Co., industrial and commercial painters and coaters. Chicago Decorating specializes in industrial plants, offices, tanks, bridges and power plants.

Origin And—

(Continued From Page 29)

to the other members his entire collaboration on any scientific question within his competence in the field of activity of the group.

Publications

The committee has published the proceedings of the second reunion (Milan, 1950—Publisher: Tamburini, Milan) and of its third reunion (Bern, 1951—Publisher: Manfredi, Milan). The committee intends to publish the Proceedings of its other reunions.* It has recently set up an editorial board comprising J. O' M. Bockris, E. Lange and G. Valensi.

2. Development and Organization.

The committee, very small in the beginning, has developed rapidly: it consists at present of 124 active members in 19 countries. In the course of its second reunion (Milan), it adopted the name "International Committee of Electrochemical Thermodynamics and Kinetics" (abbreviated to CITCE from the initials of its French name).

This development has required the setting up of an organization which, defined in rules adopted at the third reunion (Bern), rests upon the following principles:

Categories of Members:

The committee is composed of three categories of members:

Active members (persons contributing actively to the program of the committee),

Associated members (persons not necessarily contributing to this program),

Corporate members (universities and institutions of higher learning, research establishments, industrial and other organizations).

The members pay dues, which are,

however, optional for active members who do not belong to industrial or commercial organizations.

The committee is directed by a council. Each country is represented at the council by a national secretary, who is at the disposal of the members for all matters pertaining to the activities of the committee in his country, who facilitates all relations between the committee and the members in his country and who attends to the coordination of the activities of the committee with those of the scientific organizations of his country. The daily administration of the committee is in the hands of a board, a secretary general attends to the proper functioning of the entire committee.

The board and the council of the committee are at present as follows:

President: P. Van Rysselberghe (Eugene, Oregon, USA).

Vice-Presidents: T. P. Hoar (Cambridge, Great Britain), R. Piontelli (Milan, Italy).

Secretary General: M. Pourbaix (Brussels, Belgium).

Member: E. Lange (Erlangen, Germany).

Council: 1) Argentina: O. Elizaga (Santa Fé); 2) Australia: A. Walkley (Melbourne); 3) Belgium: M. Pourbaix (Brussels), secretary general; 4) Canada: F. E. W. Wetmore (Toronto); 5) Czechoslovakia: J. Heyrovsky (Prague); 6) Finland: R. Näsänen (Helsinki); 7) France: G. Valensi (Poitiers); 8) Germany: E. Lange (Erlangen); 9) Great Britain: T. P. Hoar (Cambridge), vice-president; 10) India: Sir J. C. Ghosh (Calcutta); 11) Italy: R. Piontelli (Milan), vice-president; 12) Japan: S. Tajima (Tokyo); 13) The Netherlands: E. L. Mackor (Amsterdam); 14) Norway: A. B. Winterbottom (Trondheim); 15) Spain: A. Rius (Madrid); 16) Sweden: A. U. Trägårdh (Stockholm); 17) Switzerland: K. Huber (Bern); 18) United States: East—H. H. Uhlig (Cambridge, Mass.) West—P. Van Rysselberghe (Eugene, Oregon), president; 19) Yugoslavia: M. Karsulin (Zagreb).

The headquarters of the committee are established at the University of Brussels, Laboratory of Applied Physical Chemistry, 50 Avenue F. D. Roosevelt, Brussels, Belgium.

Through the efforts of some of its members, the committee maintains very cordial relations with the International Union of Chemistry, as well as with several national organizations concerned with electrochemistry, (the Bunsengesellschaft in Germany, the Electrochemical Society and the National Association of Corrosion Engineers in the United States, the Société de Chimie Physique in France, the Faraday Society in Great Britain).

In conclusion, it is our pleasant duty to express our gratitude to F. E. C. Scheffer and U. R. Evans whose kind encouragement has greatly contributed to the birth and growth of our committee. We also wish to thank the Belgian American Educational Foundation and the Office of Naval Research for their help in bringing about our closer collaboration.

* It is likely that the proceedings of the 1952 and 1953 meetings, and possibly those of the 1949 meeting, will appear within the first half of 1954 (Publisher: Despaup-Delaunay, Paris).

1 R. M. Burns, The Importance of the Unpredictable, *J. Electrochem. Soc.*, **95**, 25C (1948).



Corrosion Abstracts

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3. CHARACTERISTIC CORROSION PHENOMENA

3.2 Forms

3.2.2, 6.4.2, 3.7.4, 3.5.8

Structure and Corrosion of Aluminium-Magnesium and Aluminium-Zinc-Magnesium Alloys. Part I. PIERRE A. JACQUET. *Rev. met.*, 49, No. 5, 339-363 (1952).

Specimens containing magnesium 6.3, silicon 0-10, manganese 0.31, iron 0.38 and copper 0.02% were heat-treated and electrolytically polished and then examined under an optical and an electron microscope and by X-rays (cf. NACE Abstract Card No. 4327, classified 2.3.9, 6.4.2, 3.7.4, 3.5.8), and treated with mercurous nitrate and under conditions of accelerated stress and galvanic corrosion. Results: 1) sensitiveness of the alloy to intergranular corrosion is strictly related to its micrographic structure; 2) intergranular corrosion is only possible if the grain boundaries are covered by a continuous film of the magnesium-rich phase; 3) structure under the electron microscope is much more revealing of the true state of the alloy so far as the separation of the intergranular constituent is concerned, provided that selective attack is avoided; 4) for the critical temperature of aging, 160°C, the decomposition of the solid solution begins at the grain boundaries and takes place in two stages; 5) character of the continuous film indicates that growth is towards the center of one of the two adjacent

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ALL—The Abstract Bulletin, Aluminum Laboratories, Ltd. P. O. Box 84, Kingston, Ontario.

AWWA—Journal, American Water Works Association, Amer. Water Works Assoc., 521 Fifth Ave., New York 17, N. Y.

BL—Current Technical Literature, Bell Telephone Laboratories, Inc., Murray Hill, N. J.

BTR—Battelle Technical Review, Battelle Memorial Institute, 505 King Ave., Columbus 1, Ohio.

BNF—Bulletin; British Non-Ferrous Metals Research Association, 81-91 Euston St., London NW 1, England.

CALCO—Calco Chemical Division, American Cyanamid Corp., Bound Brook, New Jersey.

CE—Chemical Engineering, McGraw Hill Publishing Co. 330 W. 42nd St., New York 18, N. Y.

CEC—Consolidated Edison Co. of New York, Inc. 4 Irving Place, New York 3, New York.

EL—Electroplating, 83/85 Udney Park Road, Teddington, Middlesex, England.

EW—Electrical World, McGraw-Hill Publishing Co. 330 W. 42nd St., New York 18, N. Y.

GPC—General Petroleum Corp. of California. 2525 East 37th St., Los Angeles 11, Calif.

IIM—Transactions, The Indian Institute of Metals, 23-B, Notaji Subhas Road, P. O. Box 737, Calcutta, India.

INCO—The International Nickel Co., Inc. 67 Wall Street, New York 5, New York.

IP—Institute of Petroleum, 26 Portland Place, London W.1, England.

JSPS—Japan Society for the Promotion of Science, Address: Mr. Hayata Shigeno, Secretary, Committee of Preventing Corrosion, c/o Government Chemical Industrial Research Institute, 1-Chome Nakameguro, Meguro-ku, Tokyo, Japan.

MA—Metallurgical Abstracts, Institute of Metals, London, England, 4 Grosvenor Gardens, London SW 1, England.

MI—Metallurgia Italiana, Associazione Italiana di Metallurgia, Via S. Paolo, 10, Milano, Italia.

MR—Metals Review, American Society of Metals, 7301 Euclid Ave., Cleveland 3, Ohio.

NALCO—National Aluminate Corp. 6216 West 66th Place, Chicago 38, Illinois.

NBS—National Bureau of Standards, Supt. of Documents, U. S. Gov't Printing Office, Washington 25, D. C.

NSA—Nuclear Science Abstracts, United States Atomic Energy Commission, Technical Information Division, Oak Ridge, Tenn.

PDA—Prevention Deterioration Abstracts, National Research Council, 2101 Constitution Ave., Washington 25, D. C.

RA—Refrigeration Abstracts, American Society of Refrigeration Engineers, 40 West 40th St., New York 18, N. Y.

RM—Revue de Metallurgie, Paris, France, 5 Cite Pigalle, Paris (9e), France.

RPI—Review of Current Literature Relating to the Paint, Colour, Varnish and Allied Industries, Research Association of British Paint, Colour & Varnish Manufacturers, London, Waldegrave Rd., Teddington, Middlesex.

SE—Stahl und Eisen, Verlag Stahlisen, M. B. H., Dusseldorf, August-Thyssen Str. 1. Postscheck Köln 4110, (22a) Dusseldorf, Germany.

TIME—Transactions of Institute of Marine Engineers, 85 The Minories, London EC 3, England.

UOP—Universal Oil Products, 310 South Michigan Ave., Chicago, Illinois.

ZDA—Zinc Development Association, Lincoln House, Turl Street, Oxford, England.

grains; 6) acid reagents show that the sensitiveness to intergranular corrosion already exists in the initial stage; 7) there is structural analogy between the electronic appearance of the attack at the beginning of aging and the continuous film formed later; 8) origin of the unsymmetrical behavior of the two faces at a boundary in the separation of the magnesium-rich phase and the localization of the attack cannot yet be explained; 9) when the film of intergranular precipitate has reached equilibrium, there exists an appreciable proportion of constituents in the interior of the grain, and X-rays indicate the appearance of a new solid solution poor in magnesium; 10) in addition to localized corrosion at the grain boundary, an anodic attack in sodium chloride solution produces a large number of pin holes, decreasing with increase of the period of aging; 11) continuous film of the intergranular constituent does not appear to be sensitive to acid attack; 12) the anodic phase and sensitiveness to intergranular corrosion also appears at aging temperatures above 160°C; 13) after aging at 250°C the magnesium-rich phase separates to the interior of the grains and at their boundaries in relatively large particles; 14) acid attack occurs exclusively on the precipitated particles; and 15) the structural appearance and the behavior of specimens attacked at 150° and 250°C show the nature of the difference, previously noted, of the two phases precipitated at about these temperatures. 5649

3.2.2, 6.2.5, 3.7.3

Corrosion: Knife-Line Attack of Stainless Steels. M. G. FONTANA. *Ind. and Eng. Chem.*, 44, No. 8, 87A-88A, 90A (1952) Aug.

Conditions required for knife-line attack adjacent to the weld to occur on Type 347 (18-8S-Niobium) were determined. Corrosion tests consisted of five 48-hour periods in fuming nitric acid at 160°F or boiling 6% nitric acid. Stainless steels with low carbon content take longer time at sensitizing temperatures to develop the knife-line attack. Table and illustrations.—INCO. 5485

3.2.2, 6.3.6

Intercrystalline Cracking of Brass. J. N. GREENWOOD. *Bull. Inst. Metals*, 1, No. 14, 120-121 (1952) Oct.

Work on copper and 70/30 brass in inert atmospheres suggests that intercrystalline cracking is associated with the movement and aggregation of vacant lattice sites.—BNF. 5495

3.2.2, 6.2.3, 5.3.4

Embrittlement In Plated Steel. JOHN J. DALE. *Metal Progress*, 62, 95-96 (1952) Aug.

Two examples of damage done to steel parts by hydrogen generated during electroplating operations. In each instance the defects show marked directionality. Illustrated.—BTR. 5518

3.2.3, 4.4.1, 6.2.3

Dual Adsorption of Polar Organic Compounds on Steel (Powder). N. HACKERMAN AND E. I. COOK. *J. Phys. Chem.*, 56, No. 4, 524-526 (1952).

A portion of the surface of steel powder is specific to the irreversible adsorption of alkyl carboxy acids, amines, alcohols and esters. Certain areas apparently will irreversibly adsorb either acid or amine, whereas other areas are specific to the acid or to the amine. Alcohols

and esters are not irreversibly adsorbed to the extent the acids are on fresh steel powder but appear to be irreversibly adsorbed on certain of the same sites which adsorb acids. Alcohols and esters are not irreversibly adsorbed by steel powder on which an acid has already been irreversibly adsorbed. The extent of total adsorption (reversible plus irreversible) of the second solute, for systems investigated in this study, is only slightly reduced by the pretreatment of the steel powder with another solute. The maximum amount of irreversible adsorption observed with the organic solutes is not sufficient to form a close packed monolayer over the surface of the steel powder available for krypton adsorption.—RPI. 5523

3.2.3, 4.4.6

Film Formation on Metals in Hydrocarbons. A. GEMANT. Paper, Electrochem. Soc. Meet., Philadelphia, May 4-8, 1952. *J. Electrochem. Soc.*, 99, No. 7, 279-284 (1952) July.

The rates of salt film formation on copper, lead and zinc strips in solutions of radioactive tridecanoic acid in hydrocarbon oil were measured. Rate of deposition is much higher on lead than on copper or zinc and is increased by the addition of an amine. In oxidized oil solutions the deposition rate on lead also increases (probably due to the presence of nitrogen compounds). Electrochemical deposition of the salts was also studied. 5603

3.2.3, 5.9.2, 5.9.3

Marine Corrosion. *Fairplay*, 179, 108 (1952) July; *J. Brit. Shipbuilding Res. Assoc.*, 7, No. 8, 489 (1952).

Mill scale, which adheres particularly firmly to steel rolled in modern high-speed mills, is thought to be a serious cause of corrosion in sea-water. Pickling and flame de-scaling should be more effective in removing mill scale than weathering and wire-brushing. Sand-blasting and grit-blasting are effective but sometimes impracticable.—RPI. 5616

3.2.3, 3.8.4

A Generalized View of the Scaling Behavior of Metals. J. T. WABER. *Los Alamos Sci. Lab. Metal Progress*, 62, No. 3, 76-80 (1952) Sept.

Four definite scale growth equations accepted in metal scaling research are given. The effect of time and temperature on scaling reactions and some scaling examples are discussed. Arrhenius plots of a number of results of scaling experiments at various temperatures on nickel, copper, iron and brass are shown, as well as the plot of data on the oxidation of stainless steel in O₂-N₂ mixtures at 980°C. Tables.—INCO. 5824

3.3 Biological Effects

3.3.3, 6.6.11

Action of Marine Borers and Protective Measures Against Attack. R. HORONJEFF AND D. A. PATRICK. *Proc. 2nd Conf. on Coastal Engineering*, Houston, Texas, 1951, 86; *J. Brit. Shipbuilding Res. Assoc.*, 7, No. 10, 611 (1952).

Marine borers, which exist in some form in all oceans can rapidly cause severe damage to timber harbor structures by attacking them between the mud line and the water surface. The authors describe the manner in which

the borers destroy timber and summarize information gathered by various investigators on the conditions that affect the presence of borers and the factors governing the rate of destruction. Several methods of protecting timber structures from infestation are described and the costs are compared.—RPI. 5512

3.3.4

Iron Organisms. E. G. PRINGSHEIMS. *Endeavour*, 11, No. 44, 208-214 (1952).

An account of the different types of organism responsible for the production of ochre deposits. These organisms derive at least part of their energy by oxidizing ferrous iron to ferric. Some species can also oxidize manganese, but others, such as the bacterium *Sphaerotilus natans*, cannot and thus give cleaner yellow ochres. The part played by iron bacteria in rusting is also referred to briefly. 22 references.—RPI. 5664

3.3.4, 6.2.2, 2.3.3

Influence of Sulphate-Reducing Bacteria on the Corrosion Potential of Iron. J. N. WANKLYN AND C. J. P. SPRUIT. *Nature*, 169, No. 4309, 928-929 (1952) May 31.

The potential assumed by an iron electrode in a culture of sulfate-reducing bacteria has been studied by Hadley, using a heterotrophic medium. Authors carried out experiments using electrodes in the form of strips of Armco ingot iron, immersed, under anaerobic conditions, in an autotrophic medium. After steady potentials had been attained, the medium was inoculated with sulfate-reducing bacteria. Results showed that bacterial activity under autotrophic conditions exerts little influence on the corrosion potential.—INCO. 5823

3.5 Physical and Mechanical Effects

3.5.8, 2.3.7

Fretting Corrosion. R. S. BARNETT. The Texaco Co. Paper before Am. Soc. Lubrication Engrs., Milwaukee Section, April 23, 1951. *Lubrication Eng.*, 8, No. 4, 186-189, 208 (1952) Aug.

Reviews subject and discusses recent developments in the field. Examples, detection, mechanism and mitigation of fretting corrosion; effects of load, lubricant, fits, surface finish and materials, and temperature; and work of the Coordinating Research Council, Inc. on fretting corrosion are described. Photographs and references.—INCO. 5356

3.6 Electrochemical Effects

3.6.8, 3.8.2, 3.8.4

Hydrogen Overvoltage, Electric Double Layer, and Related Questions. Genevieve Sutra. *J. Phys. Radium*, 12, No. 6, 673-681 (1951).

Recent theories of the nature and origin of hydrogen overvoltage, more especially that due to Darmon [ibid., 11, 577 (1950)] are briefly reviewed. Sutra has recently shown that the H⁺-ion is simply a proton; previous theories had conceived it as composed of a free proton encased in a molecule of water, and having the formula (H₂O)⁺. It has been customary to distinguish the minimum value of the overvoltage from that associated with variable current. Sutra considers the former voltage not to be an overvoltage, but the normal equilibrium

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voltage. The electric double layer present at a metal electrolyte interface is conceived as composed of widely spaced ions separated by water molecules. Overvoltage at the metal electrolyte interface is essential to effect penetration of the electric double layer at the interface during passage of current. The theory of overvoltage is developed on this basis, with satisfactory agreement between theoretical and experimental results. 36 references.—MA.

3.7 Metallurgical Effects

3.7.2, 6.4.2

On the Effects of Iron and Manganese on the Corrosion-Resistance of Aluminum-5% Magnesium Cast Alloy. M. KATO AND Y. NAKAMURA. *Light Metals* (Japan), No. 4, 109-112 (1952) Aug.

A study of the effects of iron and manganese on the mechanical properties of aluminum-5% magnesium alloy was carried out. Iron, within 0.5% as the limit of specification, only slightly changes the mechanical properties but decreases the corrosion resistance. Manganese up to 1% in the presence of a small quantity of iron increases the ultimate tensile strength, however, more than this amount decreases it. Manganese decreases the elongation of this ductile alloy, and the tendency was pronounced in the presence of iron. Manganese compensates for the detrimental effects of iron on corrosion-resistance and the influence of over-heating or long-time melting on the mechanical properties of this alloy. The appropriate amount 0.3-0.5% of manganese seems to be essential to this aluminum-5% magnesium cast alloy.—JSPS. 5637

3.7.2, 6.4.2, 8.9.5

The Effect of the Alloying Elements on the Properties of Aluminum-Magnesium Alloy to Be Used in Sheet for Shipbuilding. Y. MISHIMA. *Light Metals* (Japan), No. 4, 71-74 (1952) Aug.

The effect of the alloying elements upon the mechanical and chemical properties of aluminum-magnesium alloy sheet for the shipbuilding industry was studied. Sheet of 1 mm thickness in 50% cold-rolled condition was used for the tests. Tests included tensile testing, corrosion test in 3% sodium-chloride solution with hydrogen peroxide.

Aluminum-magnesium alloys, containing 3 or 5% magnesium respectively, were employed, adding either manganese or zinc up to 1.2%. Manganese improved strength only slightly, but its effect on corrosion resistance was good. On the other hand, zinc was harmful for corrosion resistance, particularly in stress corrosion phenomena, although strength could be enhanced to some extent.

Chromium up to 0.6% was added to aluminum alloys containing 3 or 5% magnesium, 0.6% manganese with or without 0.8% zinc. It was found that chromium strengthened the alloy until its tensile strength would exceed 40 kg/mm² and that its effect was more remarkable when zinc was not contained. The amount of corrosion in sodium chloride solution could be reduced when chromium was added, unless aluminum-chromium compound appeared in the microstructure. Stress corrosion could also be prevented. In aluminum-magne-

sium alloy, containing zinc, stress corrosion characteristics were much improved by the addition of chromium.

In conclusion, for an alloying element in an aluminum-magnesium alloy chromium is considered most appropriate, manganese next and zinc least. Aluminum-3% magnesium-0.6% manganese-0.6% chromium alloy, which has a tensile strength of 35.8 kg/mm² in 50% cold-rolled state, seems to be the best among the alloys considered. Higher strength can be obtained in aluminum-5% magnesium-0.6% manganese-0.4% chromium alloy, but the elongation value becomes lower. Resistance both to corrosion and stress corrosion of these two alloys seems to be satisfactory.—JSPS. 5644

3.7.2, 6.2.5, 4.3.2

Effect of the Addition of Silicon on Corrosion Resistivities of 18% Chromium-8% Nickel and 18% Chromium-14% Nickel Types Stainless Steels in Boiling Acid Solutions. H. ENDO AND A. ITAGAKI. *J. Japan Inst. Metals* (Nippon Kinzoku Gakkai-shi), 16, No. 11, 614-616 (1952) Nov.

The corrosion tests were carried out on stainless steels of 18% chromium-8% nickel and 18% chromium-14% nickel types containing 0.5 to 2.5% silicon. The corrosives were aqueous solutions of 1, 5, 10 and 20% sulfuric acid, 5% hydrochloric acid and mixtures of sulfuric acid and nitric acid in boiling conditions.

The specimens were annealed at 840°C for 2 hours or quenched in water after heating at 1090°C for 30 minutes.

The effective quantities of silicon were as follows: On 18% chromium-8% nickel types, in both cases of quenching and annealing, they were 0.5% to 2% silicon against 5%, 10%, and 20% sulfuric acid.

On 18% chromium-14% nickel types, in both cases of quenching and annealing, they were 0.5% to 2% silicon against 5%, 10% and 20% sulfuric and 5% hydrochloric acid and 2.5% silicon, in case of quenching only, against mixed acid.—JSPS. 5483

3.7.3, 8.10.3

The Effect of Water Corrosion and Shot Peening on Fatigue Strength of Mining Drill Rods. T. W. WLODEK. *Trans. Can. Inst. Mining Met.*, 55, 292-300 (1952); *Can. Mining Met. Bull.*, 45, No. 484, 470-477, disc. 477-478 (1952) Aug.

Results of research into the fatigue properties of SAE 1080 carbon steel and nickel-chromium-molybdenum steel for mining drill rods are analyzed and described in detail. The effect of water corrosion on the fatigue strength of drill rods of these two steels in the as-rolled condition were investigated and the beneficial influence of shot-peening on their dry and water-corrosion fatigue strengths determined. Eight S-N curves for as-rolled and shot-peening mining drill rods under both dry and water-corrosion conditions were derived and their shape and relative position are discussed. The main performance of the drill rods are analyzed. Illustrations.—INCO. 5836

3.7.3, 2.2.2, 2.3.9

Corrosion of Structural Spot Welds. B. KARNISKY, E. KINELSKI AND E. GRUCA. *Pullman-Standard Car Mfg. Co. Paper before AWS, 33rd Nat. Mtg.*, Philadelphia, Oct. 20, 1952. *Welding J.* (N. Y.), 31, No. 10, 903-916 (1952) Oct.

Investigation of the corrosion phe-

nomena in spot-welded joints of low-alloy, high-strength steel and evaluation of the effects of protective weld sealers. A procedure was evolved in which various types of spot-welded specimens, either stressed or unstressed, were subjected to industrial atmospheric exposure. The specimens were of 18-8 stainless steel and low-alloy steel containing 0.336-0.471% nickel. Test data were accumulated and spot weld failures were obtained in the atmospheric corrosion specimens. Metallographic examination of the failed welds, revealed additional information on the corrosion phenomena in spot welds. Results of the test indicate that spot welds may start to fail by corrosion cracking in as little as one year's time unless proper weld sealers are used in the joint and some form of periodic maintenance is performed. Photomicrographs, tables and 9 references.—INCO. 5697

3.7.3, 3.2.2

Hydrogen in Mild-Steel Weld Metal. A. L. SCHAEFFLER (Allis-Chalmers Mfg. Co.), H. C. CAMPBELL (Arcos Corp.), AND H. THIELSCH (Welding Res. Conn.). *Welding J.* (N. Y.), Res. Supp., 31, No. 6, 283s-309s (1952) June.

Review of published and unpublished information on the occurrence and effects of hydrogen in mild steel weld deposits made by shielded-metal-arc welding with covered electrodes. Hydrogen in commercial electrodes, effects of hydrogen on porosity, cracking, fisheyes, mechanical properties such as ductility, impact and fatigue strength, welding considerations, practical applications, engineering recommendations and hydrogen content of weld deposits produced from various types of electrodes including 18-8 (chromium-nickel) stainless steel are given. Tables, graphs, photomicrographs and 183 references are included.—INCO. 5788

3.7.3, 3.2.2

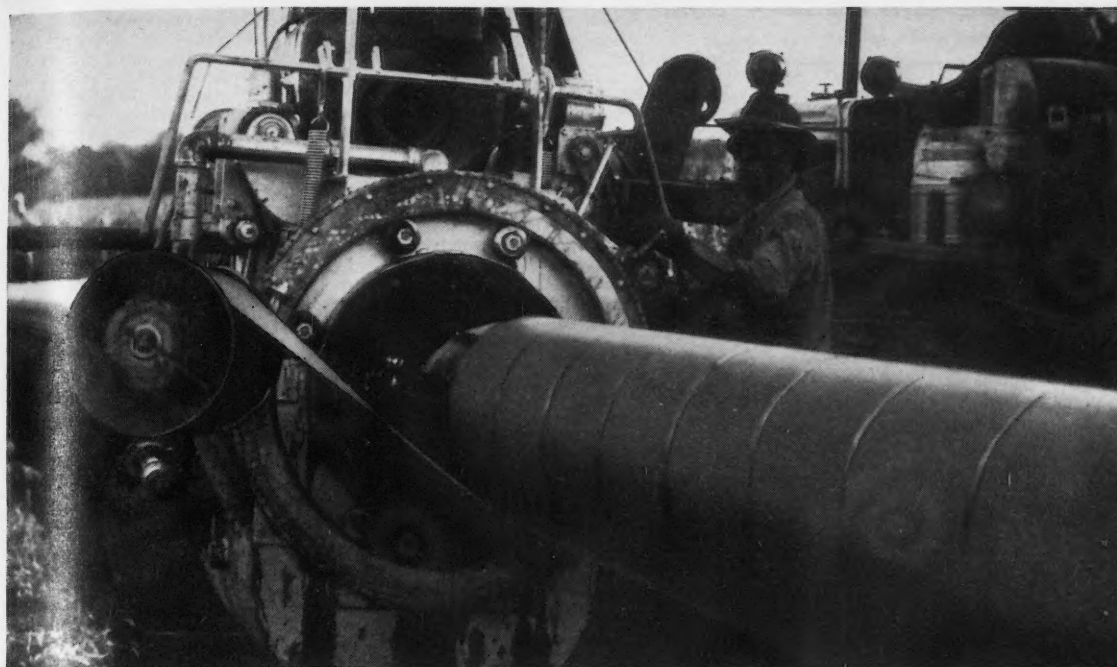
How to Increase Corrosion Resistance After Welding. T. A. PRUGER. Allegheny Ludlum Steel Corp. *Steel Horizons*, 14, No. 3, 20-23 (1952) Summer.

Tests were conducted in the laboratory on welded and heat treated samples of Type 430 and Type 442 steels with and without titanium. The samples were welded by inert arc welding, hand arc welding in which a filler rod was deposited and resistance welding. A discussion described the high points of this study of intergranular corrosion in these steels. The tests indicated a lowered corrosion resistance at weld areas and a restored corrosion resistance by simple heat treatment at 1450°F. Photomicrographs and illustrations.—INCO. 5661

3.7.3

Mir-O-Col Hard-Facing Rod No. 7. *Oil Gas J.*, 50, No. 47, 132 (1952) Mar. 31.

For oil-feed hard facings application including tool joints, churn drill bits and clutch jars. Borderline applications can now be hard-faced. Nine grades of rods are available for every type of application, for manual, electric or acetylene application. It is a cast alloy rod containing chromium, Ni-iron and other alloys. Hardness of deposit is from 54-57 Rockwell C. The new No. 7 deposits more than 97% of its alloy. Manufactured by Mir-O-Col Alloy Co., Inc.—INCO. 5652



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3.8 Miscellaneous Principles

3.8.4, 3.2.3

The Influence of Adsorption Phenomena on the Oxidation of Metals at Somewhat Elevated Temperatures. (In German). H. J. ENGELL AND K. HAUFFE. *Metall*, 6, No. 11-12, 285-91 (1952) June.

The mechanism of the oxidation of metals above room temperature is discussed in detail, with special reference to zinc and zinc alloys. An adsorption hypothesis is offered to explain how the rate of oxidation can obey a parabolic law and be, at the same time, dependent on the oxygen pressure.—ZDA. 5516

3.8.4, 6.4.2

Study of the Rate of (Anodic) Oxidation of an Aluminium-Magnesium Alloy According to the Orientation of the Crystal Face. J. HERENGUEL AND P. LELONG. *Rev. Met.*, 49, No. 5, 374-378 (1952).

A polycrystalline specimen of aluminum given a short anodic oxidation shows interference colors in white light, varying from grain to grain, when the mean thickness of the oxide film is of the order of 1 micron. Herenguel and Lelong investigated the influence of the orientation of the oxidized crystal face on the rate of growth of the film of aluminum oxide having eliminated the errors due to possible variation of the refractive index. They studied the metal + aluminum oxide film, and the metal and the film separately after the removal of the latter. The variation of the rate of oxidation depends on the true anisotropy of oxidation of the crystal and on the permeability of the oxide film already formed. The first factor operates entirely at the beginning of oxidation and the second when the anodic treatment is prolonged and it is naturally profoundly influenced by the conditions in which this is effected. The apparent anisotropy resulting from these two factors was studied by measuring the thickness of the aluminum oxide on a polycrystalline surface. 6 references.—MA. 5543

3.8.4, 6.3.19

Kinetics of Formation of Oxide Layer on Zinc. W. J. MOORE. *J. Chem. Phys.*, 20, 764 (1952) April.

It is suggested that interstitial zinc ions diffusing during the oxidation of zinc do not arise from the thermal dissociation of interstitial zinc atoms, but by some process consisting of the transfer of electrons from interstitial zinc atoms to adsorbed oxygen.—ZDA. 5578

3.8.4, 2.3.9

A Polarographic Study of the Influence of Temperature on the Rate of Oxygen Consumption by Iron, Lead and Zinc. PAUL DELAHAY, CLARENCE F. PILLOW, JR., AND DOUGLAS PERRY. *J. Electrochem. Soc.*, 99, 414-416 (1952) Oct.

Above was studied in an acetate buffer of pH 5.0 at various temperatures. Experimental data were analyzed by assuming that over-all rate of oxygen reduction is controlled by rate of chemical reaction and by diffusion of oxygen toward the metal surface. Graphs. 11 references.—BTR. 5614

3.8.4, 3.7.4, 3.2.3

The Oxidation of Metals and Alloys. E. SCHEIL. *Z. Metallkunde*, 29, 209-214

(1937) July; National Advisory Committee for Aeronautics, Tech. Mem., No. 1338, June, 1952, 16 pp.

The various types of oxidation processes occurring with pure metals are reviewed and the varying time-temperature-oxidation rate relations existing for copper, tungsten, zinc, cadmium, tantalum, aluminum and iron are explained. The effect of shape and crystal structure on oxidation is discussed. Principles derived are applied to the oxidation of alloys such as iron, copper, copper-silver and aluminum alloys, nickel steels and the oxidation-resistant alloys such as chromium-nickel and silicon steels. Illustrations include microphotographs of the structure of the oxide boundary of a steel with 4% aluminum after five hours heating at 1000 degrees, structure of oxide in cast iron, oxide isotherms of aluminum steel with 8.5% aluminum at 1000 degrees, and aluminum content in various oxide layers of aluminum steels. 29 references.—INCO. 5785

5. PREVENTIVE MEASURES

5.3 Metallic Coatings

5.3.4

Tin Alloy Plating. *Products Finishing*, 16, 76, 78, 80 (1952) Sept.

First half of the article deals with properties of tin-zinc alloy deposits and gives bath formulations and conditions for shop use. Second part discusses effect of variables on the composition and properties of tin-nickel alloys plated from a bath containing stannous chloride, nickel chloride, sodium fluoride and ammonium bifluoride. Corrosion resistance discussed and formula given.—BTR. 5736

5.3.4

Clear Protective Coatings Over Chromium Plate Systems. G. M. POY. *Rinshed-Mason Co. Precision Metal Molding*, 10, No. 11, 38-42 (1952) Nov.

Because of present restrictions on nickel, the electro-plating industry has resorted to a system consisting of copper over a base metal and then a coat of "flash-chrome." Since this system does not afford the outdoor protection of conventional chromium plate, a water-clear protective coating which will increase the outdoor durability of the copper-flash chrome system is applied. The coatings are classified into two categories: Synthetic enamels, and lacquer and solvent soluble films. Application humidity and salt spray tests and factors affecting clear protective coatings over chromium plate are discussed.—INCO. 5668

5.3.4

Recent Developments in Protective Coatings. ALLEN G. GRAY. *Metal Progress* 62, No. 5, 90-93 (1952) Nov.

This is a review article covering recent work done at the Battelle Memorial Institute and at the National Bureau of Standards on high purity aluminum deposits 0.65 mm or more thick from a plating bath consisting of a dispersion of toluene in a toluene solution of a fusion product of ethyl pyridinium bromide and aluminum chloride. In preliminary tests it was found that a bath described by Hurley and Wier produced better aluminum plate than any of the others investigated. Tests lead to the

selection of methyl t-butyl ether as the best addition agent effecting the necessary improvements in the aluminum plate. The preferred bath for aluminum plating is composed of 32 percent by weight of a fusion product of one mole of ethyl pyridinium bromide plus 2 moles of aluminum chloride, 67 percent toluene (specific gravity 0.866) and 1 percent methyl t-butyl ether. The temperature of the plating bath was maintained at 30°C. The direct current density on the cathode was 10-20 amp. per sq. ft. A superimposed alternating current of 1.5 to 2.5 volts was found to improve the physical characteristics of the deposit. The addition of methyl t-butyl ether to give a smooth plate did not affect the microstructure of the deposit. The National Bureau of Standards Method of D. E. Couch and Abner Brenner is reviewed. The special pre-treatments required when plating magnesium and aluminum as base metals are outlined with special reference to work conducted by the Dow Chemical Company based on a zinc-immersion pre-treatment. The method developed by the Aluminum Company of America utilizing a zincate immersion pre-treatment prior to plating in a copper strike bath is covered. Investigations conducted in the laboratories of Metal and Thermit Corporation have resulted in a potassium-type, tin-zinc alloy plating bath. This is especially useful in the electrical and electronic industries where a combination of corrosion resistance and good soldering characteristics are necessary. Protective coatings for molybdenum are briefly reviewed.—ALL. 5560

5.3.4, 7.7

Automatically Controlled Galvanizing Kettles. *Metal Ind.*, 81, No. 18, 349-350 (1952) Oct. 31.

Pneumatic and an electrical automatic control system for metal galvanizing are described. Use of air-operated controllers is recommended as they provide the simplest control mechanism and eliminate the corrosion problem involved. All electric contacts in the measuring and control circuits of these galvanizing kettle control systems are totally enclosed providing protection from the corrosive atmosphere of the galvanizing shop.—INCO. 5574

5.3.4

Aluminum Coating Provides Corrosion Resistant Film. *Materials and Methods*, 36, No. 2, 154, 156 (1952) Aug.

Roylac, a new spray aluminum coating, is claimed to provide a superior corrosion resistant film. The bright aluminum finish is resistant to acid-type fumes and salt or moist air. The coating is effective on galvanizing, zinc, aluminum, magnesium, steel and other basic metals. Developed by Royston Lab., Inc.—INCO. 5620

5.3.4, 2.3.7, 2.4.3

Sprayed Metal Coatings for the Protection of Steel Against Corrosion. J. C. HUDSON. *Electroplating and Metal Spraying* (England), 5, No. 7, 241-245, 247 (1952) July.

The author discusses the performance of protective sprayed metal coatings in exposure tests, the value of thickness testing for specification purposes and the painting of sprayed metallic coatings. In all three fields further research is needed, although much information has already been obtained from the in-

vestigations of the Protective Coatings (Corrosion) Sub-Committee of the British Iron and Steel Research Association. Sprayed aluminum coatings protect steel well in an industrial atmosphere and are virtually equivalent to zinc coatings of the same thickness. Existing thickness testers when used under suitable conditions will measure the thickness of sprayed coatings with adequate accuracy, but the instrument should be specially calibrated for sprayed coatings which, for equal coating weight, have a higher apparent thickness than hot-dipped or electrodeposited coatings of the same metal. It is doubtful whether chemical surface treatments are necessary before painting sprayed metal coatings, because the natural porosity of the coatings provides a good key for paint.—ALL. 5627

5.3.4, 7.6.9, 8.8.5, 4.7

Observations on the Attack of Molten Zinc on Iron. R. HAARMANN, Dusseldorf Conference Preprint No. 5, International Conference on Hot Dip Galvanizing, 1952, 22 pp. Issued by Zinc Development Assoc., Lincoln House, Turl Street, Oxford.

The various forms of attack on galvanizing pots are dealt with in turn: Flaking, pitting, grain boundary action. Considers the influence of the compositions of the bath and the steel, the temperature, etc. and gives results of a bend test (carried out in specimens immersed in the bath) for studying grain boundary attack, developed by W. Radeker. An aluminum bronze was found to be pitted by molten zinc.—BNF. 5628

5.4 Non-Metallic Coatings and Paints

5.4.5, 5.4.8, 8.8.1

Asphaltic Coatings Can Reduce Corrosion. K. N. CUNDALL, Am. Bitumuls and Asphalt Co. *Chem. Eng.*, 59, No. 11, 284, 286 (1952) Nov.

Mineral-armored, mica-filled coating, which is applied cold, is currently being used successfully to protect metals from oxidation in chemical processing plants. Other asphaltic products are used for waterproofing and for floor coverings.—INCO. 5412

5.4.5, 7.2, 7.5.5

Neoprene Maintenance Coating. L. S. BAKE, *Paint Ind. Mag.*, 67, No. 5, 10 (1952).

A slightly modified neoprene polymer before vulcanization gives low viscosity solutions, films from which cure at room temperature on mixing with a suitable accelerator. These mixtures may be used to coat the exterior of tanks and pipelines to protect them from corrosive action.—RPI. 5340

5.4.8

Under Water Paints. N. BLITZNAKOFF, *Ind. della Vernice*, 6, No. 2, 39-47 (1952).

An account of the development of anti-fouling paints is given, with particular reference to hot-applied coatings.—RPI. 5316

5.4.8, 5.4.5

Atomic Warfare and Paint. H. L. ALD-

NEOPRENE

coatings and linings

PROTECTION

against corrosive fumes or immersion

APPLIED

by roller, brush or spray

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RICH AND F. G. HECHLER. *Am. Paint J.*, 36; Nos. 47, 48, 49, 50, 52; 74+, 64+, 54+, 70+, 76+ (1952), *Ibid.*, 37, No. 3, 66+ (1952).

As a background to a consideration of the usefulness of paints in reducing the spread of fires, information obtained from the atom bomb attacks on Japan, the large-scale incendiary attacks on Germany and some extensive hotel fires in the U.S.A. is discussed. The incendiary effectiveness of an atom bomb results firstly from direct thermal radiation and secondly from its capacity for starting secondary fires, e.g., from electrical short-circuits, broken gas mains, etc. If the fires are sufficiently intense, fire storms may be produced. Reinforced concrete buildings can provide good resistance to blast, e.g., down to about 2000' from a bomb of the Hiroshima type, but unless special precautions are taken their contents will be gutted by fire. Tests are reported showing that the use of an infra-red reflective grey paint in place of a normal grey paint of the same shade will reduce absorption of direct thermal radiation by 33% and a white paint will reduce it by 83%. A major cause of loss of life in severe fires is lack of oxygen or carbon monoxide poisoning. Figures for the air consumed by complete combustion of several paint media and the carbon monoxide produced by their incomplete combustion have been computed. It is considered that several coats of combustible paint or layers of wall paper could significantly increase the risk of loss of life through these causes and that the use of a fire-retardant paint would effect a material improvement. Thick multicoat paint systems also greatly increase the risk of spread of fires. Principles of formulation of fire-retardant paints and modern test methods are briefly reviewed.—RPI. 5296

5.8 Inhibitors and Passivators

5.8.1

Prevention of Corrosion by Means of Inhibitors. R. S. THORNHILL. *Imperial Industries Ltd. Research*, 5, No. 7, 324-332 (1952) July.

Author discusses recent theories of inhibitive action and some modern applications. The properties of the more common inhibitors are described and also their industrial uses. Included in the discussion are the classification of inhibitors, cathodic and anodic inhibitors and inhibitors for acid solutions. The inhibitors described are oxygen, sodium hydroxide, sodium carbonate, sodium benzoate, sodium phosphate, sodium bicarbonate, sodium silicate, sodium chromate, sodium nitrite, sodium polyphosphates, oil emulsions and vapor phase inhibitors. Illustrations and references are given.—INCO. 5782

5.8.2

Mechanical Aspects of Corrosion Inhibitor Injection. D. J. ELLIOTT. *Texsteam Corp. World Oil*, 135, No. 6, 190-192, 154 (1952) Nov.

How to design corrosion inhibitor injection systems, automatic or semi-automatic. Suggestions for the stick method, automatic slugging, continuous annulus injection and inhibitor injection system in gas lift wells are covered. Diagrams.—INCO. 5606

5.8.2, 8.4.3

Visco 953-X. *Oil Gas J.*, 50, No. 47, 132 (1952) Mar. 31.

A chemical inhibitor for corrosion control in oil production which is a polar-type organic material, having a complex synthetic composition with medium fluidity at atmospheric temperatures, can be adsorbed on metal surfaces to form a lasting film. It is a dark colored liquid containing no inorganic salts or alkalies, no corrosive properties, basic in reaction, having a pH of 9-10, is insoluble in oil and dispersible in water. Manufactured by Visco Products Co., Inc.—INCO. 5720

5.8.3

Condensed Phosphates and Corrosion Control. B. RAISTRICK. *Chemistry & Industry*, No. 19, 408-414 (1952) May 10.

Discusses relationship with the application of condensed phosphates to stabilize supersaturated cadmium carbonate solutions, the general mechanism of corrosion and of inhibitor action, the possibilities of cathodic and anodic control with condensed phosphates, tuberculation, pitting and the successful use of metaphosphate at low pH, the role of cadmium in corrosion control and the protection of non-ferrous metals. Experimental procedures are described. The use of small concentrations of condensed chain phosphates for the control of corrosion by natural waters is very closely allied with the use of similar concentrations for inhibiting the deposition of calcite from supersaturated cadmium carbonate solutions. Illustrations and references are included.—INCO. 5746

5.8.3, 3.8.4

The Influence of Inhibitors on the Dissolution of Iron in Acid Solution. J. ELZE AND H. FISCHER. *J. Electrochem. Soc.*, 99, No. 6, 259-266 (1952) June.

A fundamental study of the mechanism of inhibitor action in hydrochloric acid solution. Inhibitors which are otherwise effective have little influence on the reduction of ferric ions at a platinum cathode and as a result of these studies the relatively slight effect of inhibitors on the dissolution of iron in the presence of oxygen is explained, since inhibitors have only a slight effect in increasing the metal solution over-voltage. They prevent the dissolution of iron by direct hydrochloric acid attack by raising the hydrogen over-voltage at the iron surface, thus preventing hydrogen evolution.—ZDA. 5487

5.8.3

Precipitation of Colloidal Ferric Oxide by Corrosion Inhibitor Ions. W. D. ROBERTSON. *Yale Univ. J. Phys. Chem.*, 56, No. 5, 671-672 (1952) May.

Relative precipitating power with respect to a ferric oxide sol of anions employed as corrosion inhibitors was determined. It was concluded that the colloidal precipitating power of anions is not a significant factor in the corrosion inhibition mechanism. Table and five references are given.—INCO. 5747

5.8.4, 3.2.2, 3.6.2

Protection of Metals Against Pitting, Tuberculation, and General Corrosion. H. LEWIS KAHLER AND PHILIP J. GAUGHAN. *Ind. and Eng. Chem.*, 44, 1770-1774 (1952) Aug.

This paper covers the history on the use of the chromate inhibitor and points

out that chromate, although one of the best treatments for saving steel, gives pitting and tuberculation when used in concentrations insufficient to stop total attack. Phosphate in low concentrations (0 to 10 ppm) at pH 7 to 9, and in higher phosphate concentrations (10 to 100 ppm) in pH range of 5.5 to 7 gave severe pitting tendencies, being worse in this action than chromate alone. Phosphate at high concentrations aided by synergists such as complex cyanides at low pH were found to be practically equivalent to phosphate alone. In research to overcome the shortcomings of phosphate and chromate inhibitors used alone, this combination of two anodic inhibitors, phosphate-chromate, was used over a select pH range and was found to control pitting and tuberculation. In exhibiting this new mechanism for the control of pitting and tuberculation, the phosphate-chromate treatment also showed it could control general corrosion, saving as high as 99% steel at total concentrations as low as 60 ppm. In reducing the number of pits compared to single chromate or phosphate inhibitors, the combination phosphate-chromate treatment exhibited a new mechanism as though the combination of phosphate and chromate was acting as a new agency and not as two single anodic inhibitors. Field data from plants now using the combination treatment are presented to show that the laboratory research data has been verified in extensive plant practice.—NSA. 5568

5.9 Surface Treatment

5.9.4, 6.4.2

The Anodic Oxidation of Aluminium. G. C. THOMPSON. *Electronic Eng. (England)*, 24, No. 292, 281-283 (1952).

The theory of anodizing is discussed, and details of the chromic-acid process (Bengough-Stuart process) and the sulfuric-acid process are given. The chromic-acid process is unsuitable for use with aluminum alloys containing 5% copper, but the corrosion-resistance of the film produced by it is better than that produced by the sulfuric-acid process. The sulfuric acid oxide film is transparent, whereas the chromic acid film is not. Notes are given on the final treatment, multichrome dyeing and a method of removing patchy and streaky films before re-anodizing.—ALL. 5786

7. EQUIPMENT


7.1 Engines, Bearings and Turbines

7.1, 3.5.9

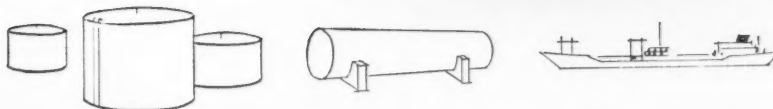
Ryman Alloy for Exhaust Systems Resists Scaling at 1800° Temperatures. H. BERLINGHOF, JR. *Ryan Aeronautical Co. Western Metals*, 10, No. 7, 42-43 (1952) July.

When Ryan exhaust systems were ordered for tanks and personnel carriers, a new alloy, named "Rynalloy," was specially formulated by the company's development laboratory. Two types of ball-and-socket assemblies are provided for the personnel carriers. Both assemblies contain stainless steel tubes, while the smaller unit contains cast balls of Ni-Resist and the larger assembly contains cast balls of the new "Rynalloy."—INCO. 5429

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Para-dichlorobenzene • Ortho-dichlorobenzene • Monochlorobenzene

7.1, 2.4.2

Behavior of Liquid Hydrocarbons with White Fuming Nitric Acid. C. H. TRENT AND M. J. ZUCROW. *Purdue Univ. Ind. & Eng. Chem.*, 44, No. 11, 2668-2373 (1952) Nov.

Experimental study of the combustion behavior of a number of pure hydrocarbon compounds with white fuming nitric acid under conditions simulating those found in an actual rocket motor. Testing apparatus for measuring the rate of temperature rise consists of a glass reactor, a thermocouple fabricated from platinum and platinum-10% rhodium wire and a stirring mechanism of stainless steel housed in a stainless steel cylinder. Tables, graphs and 17 references.—INCO. 5825

7.1, 4.4.7

Engine Lubricating Oils: The Performance of Premium and Heavy-Duty Qualities. J. G. WITHERS. *Automobile Engr.*, 42, No. 558, 387-393 (1952) Oct.

Development of acids in the oil at high temperature or the use of an oil without an oxidation inhibitor can cause heavy corrosion of copper-lead bearings. Where these bearings are used with sump temperatures in excess of 250 degrees F, it is important that the oil reach the standard set by the MIL-O-2104 specification as far as the Chevrolet L-4 tests is concerned. The use of suitable filters, together with their proper maintenance, will almost eliminate wear from abrasion, 10 references.—INCO. 5833

7.2 Valves, Pipes and Meters

7.2, 6.6.8

Plastic and Glass Fiber Pipe Has New Basic Uses. *Petroleum Engr.*, 24, D51 (1952) Mar.

Describes thermosetting, glass-fiber reinforced, plastic pipe which withstands high pressures, yet is light weight; it need not be coated, wrapped, or given cathodic protection; can be placed by hand or with light machines and joints bent to conform with ditch contours.—BTR. 5691

7.2, 6.2.5, 6.3.10, 2.3.4

Accelerated Corrosion Tests of Steels (and Nickel Alloys). JAMES T. WABER AND SANTON WABER. U. S. Atomic Energy Commission Publ., 1952 (LA-1313), 27 pp.

Various materials were subjected to general corrosion tests to assess their suitability for duct work; they included "A" nickel, "B" Monel, Inconel, Inconel B and Types 316, 316 ELC and 318 stainless steel. Accelerated corrosion tests were made in a simulated hood with the metals in contact with the fumes from five concentrated acids and one alkali and welded specimens were tested for stress-corrosion cracking and for intergranular attack of the heat-affected areas. The stainless steels and Inconel showed the best resistance to general chemical attack and Inconel was also free from stress-corrosion susceptibility and pitting. These results are in general agreement with commercial experience. Seamless and welded stainless-steel tubing cracked profusely after a few hundred hours stress-corrosion tests in the standard magnesium chloride reagent. Considerable protection was afforded by heat-treating the tubing at 1950 degrees F (1065 degrees C) for 30 minutes followed by air-cooling and pickling the steel before passivation.—MA. 5838

7.4 Heat Exchangers

7.4.1, 8.8.1, 3.7.3

Welding Heat Exchangers for the Chemical Industry. JOHN W. MORTIMER. *Welding J.* (New York), 31, 387-392 (1952) May.

Different types of heat exchangers and fabrication procedures for their manufacturers. Emphasis on welding, but includes choice of alloys for different parts and service conditions, inspection, testing and finishing. Numerous illustrations.—BTR. 5585

7.4.2, 6.3.6

Tin Bronze Condenser Tubes. Tin and Its Uses, No. 26, 6-7 (1952) May.

Review of the situation of tin bronze condenser tubes. Their adoption today would effect an immediate economy in the use of nickel. Examples of the practicability of the 10% tin bronze tubes are given. Charts comparing 2% aluminum brass, 70/30 copper-nickel and 10% tin bronze are shown.—INCO. 5822

7.5 Containers

7.5.2, 5.4.3

Organic Protective Coatings for Metal Cans. S. L. FLUGGE. Continental Can Co., Inc. Paper before the Chemical Institute of Canada, Protective Coatings Div., 35th Ann. Conf., June 2-4, 1952, Montreal. *Chem. Canada*, 4, No. 10, 31-34 (1952) Oct.

Attempts to develop an all-purpose protective coating have not been successful and from 10 to 20 different protective coatings may be needed to meet the requirements of the many products now packed in cans. Various coatings including the oleoresinous, vinyl, phenolic, and the wax types are described. Properties, evaluation, and applications of can liners are considered. Synthetic resins have replaced the natural resins and ester gum. Can linings containing zinc oxide were developed for corn cans but were extended to other products and were called C-enamels.—INCO. 5444

7.5.5

How to Protect Storage Tanks. *Oil Gas J.*, 51, No. 11, 107 (1952) July 21.

Cleaning accounts for 60% of the total labor costs or about 37% of the total over-all cost of the tank-painting program. Four basic methods are used for cleaning steel surfaces. They are wire brushing, sandblasting, pickling and flame-priming. The first two methods are most universally employed. Results of tests proved that application of the first prime coat by brush would give longer service life than by spray. Two types of protective coatings most generally used are paints and mastics. Photographs.—INCO. 5687

7.5.5, 5.2.1

Cathodic Protection of Steel Water Tanks. C. KENYON WELLS. *J. Am. Water Works Assoc.*, 44, 428-434 (1952) May.

Procedures and experiences of Long Beach Water Dept., Long Beach, Calif. They indicate that cathodic protection of the interior surfaces of steel water-storage tanks is limited to those areas below the average high-water line. It still remains necessary to protect those areas above this level with some type of coating. Use limited to non-ice-forming months of the year.—BTR. 5828

7.5.5, 5.4.5, 5.4.2

How to Protect Storage Tanks. J. S. COOK. Humble Oil & Ref. Co. Paper before API, 17th Midyear Mtg., San Francisco, May 12-15, 1952. *Oil Gas J.*, 51, Nos. 3, 4, 5, 7; 221, 117, 113, 109 (1952) May 26, June 2, June 9, June 23.

Discussion of the coal-tar-base bottom coatings for storage tanks. Surface preparation including degreasing and sand blasting, priming solution and application of the enamel coating are reviewed. Pneumatic application of concrete mortar (Gunitite) on internal surfaces of tanks for protection against corrosion is also discussed.—INCO. 5391

7.6 Unit Process Equipment

7.6.4, 3.5.2

External Boiler Deposits. H. E. CROSSLAND. *J. Inst. Fuel*, 25, 221-225 (1952) Sept.

The problem of the fouling of water-tube boilers by external deposits has received a considerable amount of attention from many investigators. In the present paper special attention has been given to the aspects of this trouble which are most concerned with the inorganic minerals in the coal and their behavior in boiler systems. The different types of deposits are discussed, and correlations are suggested between the severity of trouble from these types and the amounts of various constituents such as chlorides, sulfur and phosphorus in the coals burnt. Consideration is also given to the factors influencing the vaporization of mineral substances in boilers and the subsequent condensation of these vapors on heating surfaces. In addition to the formation of bonded deposits due to chemical influences, other deposits are formed by physical means concerned directly with the temperatures of the gases and the metal heating surfaces.—TIME. 5407

7.7 Electrical-Telephone and Radio

7.7.2.3.5

Oxidation of Alloys by the Wire-Life Test Method. ANTON DE S. BRASUNAS AND HERBERT H. UHLIG. *Am. Society Testing Materials Bull.*, 182, 71-75 (1952).

In the A.S.T.M. wire-life test for evaluating electric heating wire (method B76-39) the wire is heated electrically for 2 minutes on and 2 minutes off, and the test is continued until the wire fails or the electric resistance increases by 10%. Brasunas and Uhlig show that a considerable drop of temperature occurs during this test and describe a modified version of the test in which the temperature of the wire is controlled throughout as well as the humidity of the surrounding atmosphere. This test is used for rapid evaluation of alloys and surface treatments for high temperature oxidation. Results are given to show the effect of temperature and of relative humidity of the atmosphere for 80-20 nickel-chromium alloy. The effect of contaminating the wire surface with various salts before test is described, and results are given for the effects of pre-treatments by exposure to moist hydrogen for various temperatures and times. Considerable improvements in life could be obtained.—MA. 5405

7.7, 3.6.9

Interference from Cathodic Protection Rectifiers. D. W. R. COBBE. *Post Office*

March, 1954

Elec. Engrs. J., 45, No. 2, 68-71 (1952) July.

Rectifiers used for cathodic protection of pipelines may cause serious interference to telegraph and telephone circuits, which can be eliminated by smoothing equipment.—BNF. 5370

7.7.6.3.21

Embedded Selenium Rectifiers. B. PARSONS AND A. M. D'URSO. *Elec. Mfg.*, 50, 134,232 (1952) Sept.

Points out that the above reduce space, weight, and cost; and improve vibration and corrosion resistance. Three types of construction are compared.—BTR. 5474

7.7.6.4.2

Aluminium Conductor System. *Elec. World*, 137, No. 24, 215 (1952) June 16.

A new aluminum (third rail) conductor system eliminates the need of improvising structural shapes such as steel railroad rails or steel or copper angles, tees, bars or wire to feed power moving equipment. Maximum efficiency of current transfer is accomplished through careful integration in design of collector, conductor and accessory components. Other advantages are elimination of corrosion problems, maintenance of conductor alignment, reduction of shipping, handling and erection costs. Aluminum in this system may be spaced on close centers to achieve low reactance drops previously obtainable only with copper systems. The system, developed by the Electric Service Manufacturing Company, has been named "Keystone."—ALL. 5461

7.7.6.4.2

Corrosion Resistance of Aluminium and "Aldrey" Cables. G. DASSETTO. *Aluminium Suisse* (Switzerland), 2, No. 3, 96-99 (1952) May.

Several transmission lines in France, all constructed between the years 1926 and 1929, using aluminum and "Aldrey" cable, have remained in perfect condition during the intervening years. The cable was given a thick coating of grease each year but was otherwise untreated. The atmosphere was in some cases saturated with salt water, and in others charged with corrosive industrial vapors. In Venice, however, on the island of Pellestrina a line situated 55 meters from the sea coast was found to be quite severely corroded, just previous to World War II, when the records were lost. Salt had seeped into the strands of cable and the rain had failed to either dissolve or wash it away. Considerable corrosion had resulted. "Aldrey" cables installed in the tropics have given excellent satisfaction. In most cases of corrosion it was found that the cable had contained one or other impurities which led to its breakdown. In all cases the "Aldrey" cable was shown to be as resistant to corrosion as the cable of high purity aluminum.—ALL. 5439

7.7.6.4.2, 4.2.5

The Behaviour of Stranded Aluminium Conductors in Marine Atmospheres. F. A. CHAMPION AND E. W. SKERREY. *Light Metals* (England), 15, No. 174, 286-290 (1952) Sept.

Both satisfactory and unsatisfactory service experiences of steel-cored aluminum (S.C.A.) conductors are described. Field trials up to 72 months at three British and one African site compare effects of oil, bitumen and lanolin with or without zinc chromate or tetroxy-

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chromate as protectives, using both S. C. A. and Silmalec (0.5% magnesium, 0.5% silicon) stranded conductors. Adhesion is more important than cohesion in protectives.—BNF. 5347

7.7, 6.4.2

Aluminium Versus Copper. F. L. CHURCH. *Modern Metals*, 8, No. 4, 25-32 (1952) May.

The trend to greatly increased aluminum usage by the electrical industry is influenced by the greater availability of aluminum and its relative cheapness. General Electric has built three 200,000-kilowatt generators with aluminum wire windings, and one of the company's standard washing machines is powered by a motor with aluminum windings. In France the company is making cast aluminum rotors for asynchronous motors with ratings of up to 1200 horsepower. A.C.S.R. accounts for eight of every ten miles of line conductor operating above 150,000 volts. The Cleveland Electric Illuminating Co. is adopting aluminum in some of its distributing network. Aluminum conductor is being used to transmit 4340-volt power from substations where it is stepped down to the 120 to 240 voltage required by customers. E. C. (electric conductor) 99.5 percent pure aluminum as used in insulated conductor has certain advantages over copper. It has better resistance to corrosion in sulfurous atmosphere, and it is entirely inert to rubber compounds. Aluminum conductors may be joined and connected by welding, soldering and mechanical conductors. One of the newest electrical conductors is a construction called "Triplex" consisting of a single self-supporting cable made up of three wires, two of which are insulated and loosely wound around a third bare "ground" wire. Western Electric is producing aluminum wire on a commercial basis for delivery to telephone companies.—ALL. 5397

7.9 Specifications

7.9, 1.6, 7.2, 6.2.1

ASTM Specifications for Steel Piping Materials. Book, 384 pages, 1952. American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa. \$3.50.

Contains in latest approved form 56 ASTM specifications for carbon and alloy-steel pipe and tubing, including stainless. Materials covered include: pipe used to convey liquids, vapors, and gases at normal and elevated temperatures; still tubes for refinery service; heat-exchanger and condenser tubes; boiler, superheater, and miscellaneous tubes. Includes specifications for castings; forgings and welding fittings; bolts and nuts.—MR. 5419

7.10 Other

7.10, 2.3.5

The Ferroxyl Reagent Applied to a Study of Knitting Needle Corrosion. F. BRYANT. *Textile Research J.*, 22, 553-554 (1952) Aug.

Tests were carried out on the corrosion problem and the above method proved satisfactory. Needles are of alloy steel.—BTR. 5404

7.10, 8.4.3, 5.11

Some Considerations in Selection of Sucker Rods. K. N. MLLS. (Ideco). *Pe-*

troleum Engr., 24, No. 4, B-12+ (1952) Apr.

Elasticity, fatigue and economics in designing sucker rods and laboratory fatigue testing are reviewed. Improper handling creates the most common stress raisers. The endurance limit of carbon and alloy steels is related to the tensile strength and this relationship depends on the hardness of the steel. Reduction of the endurance limit of sucker rods subject to corrosion fatigue in water cut or corrosive well fluids is considered. Pressure of pure water reduces the endurance limit of steel to less than that found in air. Hydrogen embrittlement of steel, use of alloying elements such as nickel, chromium, molybdenum and copper to increase hardenability of steels, stress range, calculation of sucker rod load, natural frequency of longitudinal vibration and pumping speed, rod weight and maximum permissible stress level are discussed. Tables, graphs, 7 references.—INCO. 5702

8. INDUSTRIES

8.1 Group 1

8.1.2, 7.10

Atmospheric Exposure Tests of Nailed Sheet-Metal Building Materials. T. H. OREIN. U. S. Dept. of Commerce, Building Materials and Structures Report No. 128. March 28, 1952. 24 pp.

The tests reported were undertaken to show how improper installation could accelerate the corrosion of nailed building materials, and to determine their corrosion resistance on atmospheric exposure. The materials tested were aluminum, aluminum alloys, zinc alloys, galvanized steel and aluminum coated steel. The zinc alloy sheets were nailed to wood with bare steel or galvanized nails, using lead or neoprene washers or no washers at all. The galvanized sheets were fixed with nails made of aluminum, steel (bare, resin-coated, galvanized or cadmium plated) and copper. After two years there was very little corrosion of any of the galvanized sheets, though contact with bare steel, copper and lead had somewhat increased the corrosion of the outer zinc layer. Aluminum or galvanized nails are recommended, with neoprene rather than lead washers.—ZDA. 5721

8.1.2

Painting Steel Bridges. R. MANSELL. *Can. Paint & Varnish Mag.*, 26, No. 8, 5-6+ (1952).

The cleaning, preparation and painting of steel bridges are discussed. Paint systems used on certain bridges exposed to particular types of weather conditions are described.—RPI. 5594

8.1.2, 6.2.5

Type 430 for Roof Drainage. R. E. PARET. *Am. Iron & Steel Inst. Sheet Metal Worker*, 43, No. 9, 37-38+ (1952) June.

Some roof installations of Type 430 chromium stainless steel which have been in service for a number of years and current installations in the residential field are reviewed. A group of houses in L. I. were equipped with Types 301 and 430 and no difference in service was found after one year. The chromium content makes the alloy resistant to corrosion and the nickel content increases its workability. Fabrication, soldering, field installation and painting are discussed. Although Type 430 does not

bend with the ductility of 18-8, bends in sheet metal work can be made satisfactorily. Illustrations.—INCO. 5677

8.1.4, 6.2.5, 2.2.3

Corrosion Studies and the Use of Stainless Steel at the Back River Sewage Treatment Works, Baltimore, Maryland. C. E. KEEFER and KENNETH M. HUSTON. *Sewage and Industrial Wastes*, 24, 1209-1220 (1952) Oct.

Describes corrosion tests on stainless steel, aluminum, nickel alloys, copper, cast and wrought irons and mild steel. Presents plant-scale experience with stainless steel in primary settling tanks, in ferrous sulfate chlorinating tanks, in downspouts and gutters, in centrifugal sludge pump and in vacuum filters. Concludes with effect of mechanical properties and applications for stainless steel. Photographs and tables.—BTR. 5554

8.1.4, 5.4.5

Paint Protection of Sewage Works Structures. W. T. McCLENAHAN. *Sewage and Industrial Wastes*, 24, 1-23 (1952) Jan.

The various types of protective coatings available and suitable for metals used in and about sewage works.—MR. 5581

8.1.4, 5.8.3, 8.9.3

Action of Sodium Silicate as a Corrosion Inhibitor in Water Piping. LEO LEHRMAN and HENRY L. SHULDENER. *Ind. and Eng. Chem.*, 44, No. 8, 1765 (1952) Aug.

Anti-corrosion treatment of water supplies of several hundred buildings in a number of different cities, during the past 25 years, has shown that one of the most effective and economical treatments applicable to potable water is the continuous addition of sodium silicate in amounts equivalent to 8-12 ppm as silica. A protective film which is predominantly silica forms on the inside surface of the pipe; it remains a thin film and does not build on itself. The theory of this formation of a thin protective film and experimental data are discussed.—NALCO. 5796

8.2 Group 2

8.2.1, 8.2.2, 6.2.2

Iron Atoms in the Service of the Electrical Engineer. CHARLES GOODEVE. *Engineer*, 193, 599-600 (1952) May 2.

Extracts from Kelvin Lecture. Properties, fundamental aspects, such as atomic and crystal structure and their effects on mechanical and physical properties, including corrosion, creep, high-temperature behavior and magnetic properties.—MR. 5607

8.2.1, 7.7, 3.6.4, 3.6.6

Finishes for Communications Equipment with Special Reference to Electroplate Coatings. E. C. J. MARSH. *J. Electrodepositors' Tech. Soc.*, 28, 69-88 (1952).

Considerations in choosing type of finish, accelerated testing, handling and assembly, service conditions, electroplating (zinc, cadmium, nickel, nickel-chromium, tin-zinc and tin-nickel on steel; plating on copper-base alloys; silver on aluminum; tin on magnet alloys; tinning for soldering) and plant. Includes tables of contact potentials in sea water and metal-to-metal combinations found satisfactory in practice.—BNF. 5608

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Examination of longest and oldest continuous mastic application to a product pipe line in the Mid-Continent area . . . after 9 years of service. (Extracted from "Examination of 335 Miles of Asphalt Mastic Coated Pipe," by Donald E. Miltner, published in July, 1953 Corrosion, publication of the National Association of Corrosion Engineers.)

"The 335 miles of 6% inch OD pipe line extends from Topeka, Kansas, to Sioux Falls, South Dakota. A lightweight pipe of 14.96 pounds per foot was used in this construction because the line was to be coated in its entirety and in addition maintained under cathodic protection. This weight of pipe was selected to allow an adequate factor of safety for the normal range of operating pressures and yet provide for maximum economy in overall investment costs. Five cathodic protection rectifier units were installed soon after construction of the line was completed.

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2. Inspection of a representative number of indicated coating failures.
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Results. "This survey indicates that the inspection made of the coating during manufacture and construction of the line was of a high order.

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"The total area of coating adversely affected from any cause whatsoever was approximately 50 square feet in over 3 million square feet of pipe coating."

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8.3 Group 3

8.3.2, 8.3.4, 6.4.2

The Corrosion of Aluminum and Its Alloys by Wine. L. GENTILINI AND G. MISSIER. *Aluminio*, 21, No. 2, 130-134 (1952) May.

Strips of high purity aluminum and certain aluminum alloys—Alumin, Per-alumin and Anticorodal—were immersed in wine of three different qualities for 30 days at 20 and 40 degrees C. At the end of this period it was found that the wine had corroded all strips, although the high purity aluminum was least damaged. The wine had also taken on a metallic taste which made it unfit for consumption. In a second trial, one-liter bottles were used, the inside of which had been coated with Periplast paint (thermo-hardened phenolic resin). The bottles were Alumin alloy and the conditions of storing were similar to those used when the strips were tested. After one month at 14-16 degrees C the interior of the bottles was not damaged, nor was the taste of the wine changed.—ALL. 5494

8.3.5, 6.4.2

For Selling Meat—Aluminum Platters and Pans. *Modern Metals*, 8, No. 3, 49-54 (1952) Apr.

Trays, pans and a new product, Pan-L-Cart, a light and sturdy pushcart, intended for meat and other foods, are made of aluminum. The principal reason for using aluminum is the metal's superior corrosion resistance. The new 150S alloy takes a good anodized finish.—INCO. 4179

8.3.6

Corrosion in the Sugar Refining Industry. U. STARK. *Werkstoffe u. Korrosion*, 3, No. 12, 441-444 (1952) Dec.

The normal, slightly alkaline, cane juice does not attack steel equipment. Under certain conditions which occur in the course of processing, a decomposition of some of the constituents of the cane juice takes place. This causes acids to form, which attack the material of which the pipe lines are constructed, thereby generating hydrogen at high temperatures. Similar corrosion results and be obtained in the laboratory by the use of dilute acetic acid.—INCO. 5761

8.4 Group 4

8.4.2, 5.7.7, 5.8.2

Gas-Condensate Well Corrosion . . . What it Costs and How to Combat it. T. S. ZAJAC. Shell Oil Co. Paper before NGAA, Corrosion Research Project Comm., 1952, Houston. *Oil Gas J.*, 51, No. 14, 108+ (1952) Aug.

Summary of what is being learned about this costly problem—what causes it, how to detect and evaluate it, and the techniques and measures for controlling it. Suitable alloys were found for well-head assemblies and for special tools installed in tubing strings. A variety of chemicals were found to be satisfactory and economical for use as neutralizers and inhibitors. Several tubing alloys and coatings are in use, and indicate that they will be economic solutions to the tubing-corrosion problem. The average uncontrolled corrosion cost is \$3.59/MMcf while the average range of chemical treating costs is \$0.25-0.75/MMcf. Tables and references.—INCO. 5840

8.4.3, 7.6.8

Maintenance is a Major Challenge at This Indonesian Refinery. *Oil Gas J.*, 51, No. 33, 274-276 (1952) Dec. 22.

Maintenance problem developed during early postwar operations was corrosion of distillate worms. The source of the trouble was due to the breakdown of salt in crudes to form hydrochloric acid. Ammonia was injected to neutralize these acidic condensates since little could be done to change operations or remove salts prior to crude processing.—INCO. 5688

8.4.3, 3.2.2

Some Corrosion Problems in Petroleum Refineries. JOHN F. MASON, JR. *Petroleum Engineer*, 24, No. 2, C10, C13-C14, C16-C18 (1952) Feb.

Presents an analysis of 15 problems encountered. Each specimen was examined for cracking, pitting and other forms of local attack. Method of test was in accord with ASTM Recommended Practice for Conducting Plant Corrosion Tests. Metals involved include nickel, stainless, carbon steel, cast iron, copper and alloy steels.—BLR. 4197

8.4.3, 6.4.2

Aluminum in the Petroleum Industry. *Modern Metals*, 8, 34-36 (1952) July.

Aluminum for such applications as river and bridge crossings, underground lines, sucker rods, exploratory rigs, heat exchangers and instrument lines.—MR. 5795

8.4.3, 5.8.2, 7.4.2

How to Control Internal Corrosion of Crude Still Condensers. M. J. WILCOX AND F. M. WATKINS. Sinclair Refining Co. *Oil Gas J.*, 50, No. 45, 290-293 (1952) Mar. 17.

Organic inhibitors used to protect crude still condenser systems along with corrosion resistant alloys. Dosage, sampling and analysis of results are discussed. In the condenser system, heat exchangers are Monel lined and the bundles are assembled with Admiralty tubes. Tables and graphs are included.—INCO. 5814

8.5 Group 5

8.5.3, 7.6.6

Corrosion of Alkaline Pulping Digesters. Analysis of Corrosion Questionnaires. R. S. PEOPLES AND G. L. ERICSON. *TAPPI*, 35, 403-409 (1952).

Tabulates results of extensive questionnaire sent to kraft and soda pulp mills in the U. S., Canada and Australia to obtain data helpful in correlating information of above. Additional work and tests are suggested.—BTR. 5673

8.5.3

Nickel Plating Large Drum Dryer. *Electroplating & Metal Spraying*, 5, No. 7, 229 (1952) July.

Illustrations show a large drum drier used in the manufacture of machine glazed paper. The application of a nickel deposit on the cast iron drum gave good resistance to corrosion and a superior glaze to the paper.—INCO. 5491

8.5.3

Stainless Steel Used to Cut Anglo-Canadian Blowpit Leaks. *Paper Ind.*, 33, No. 12, 1421 (1952) Mar.

The Anglo-Canadian Pulp and Paper Co., Quebec City, has used Type 316 stainless steel to prevent leakage and failure in blowpits. Stainless steel tanks were installed to handle the pulp as it

blows from the digesters. Stainless steel valves and pipes under the tanks are closed off and water is fed into the unit through high-pressure nozzles. Illustrations.—INCO. 5664

8.5.3, 4.3.7

Peroxides. J. S. REICHERT. E. I. du Pont. *Paper Trade J.*, 135, No. 20, 230-243 (1952) Nov. 14.

In the peroxide bleaching process, stainless-steel, tile-lined concrete and rubber-lined steel are used as structural materials because of their resistance to corrosion, catalytic effect on peroxide decomposition and pulp discoloration. "Transite" and wood are suitable for some applications. Diagrams and graphs.—INCO. 5749

8.6 Group 6

8.6.2, 5.3.2, 4.4.2, 4.3.3

Nickel Use in Soap Plants. *Soap Sanit. Chemicals*, 28, No. 7, 85 (1952) July.

Standard Ni-Lectro-Clad pipe and fittings with .007-.010-inch pure nickel permit economical corrosion control in soap production. Photograph shows the contrasting effect of hot caustic and fatty acid on Ni-Lectro-Clad and seamless steel pipe. Side by side in a process line for over two years, surface of nickel is unblemished and promises many years of economic service.—INCO. 5773

8.8 Group 8

8.8.1, 5.4.5, 6.6.8

Plastic and Corrosion. V. EVANS. *Chem. Products*, 15, No. 1, 17-21 (1952).

When chemical plant and equipment is exposed to corrosive conditions some protection is given by surface coatings, particularly polyvinyl chloride copolymers. Small metal vessels may be protected with a stoved phenol/formaldehyde resin. Plastics such as polyethylene, polyvinyl chloride, neoprene, plastisols, poly-Me methacrylate, etc., find uses in lining vessels or in the fabrication of equipment. Corrosion-resisting cements are made from phenol/formaldehyde, furane or cashew nut shell liquid resins and inert fillers.—RPI. 5484

8.8.1, 3.7.3

Fabrication of Chemical Plant. H. B. FERGUSON. G. A. Harvey & Co. *Chem. & Process Eng.*, 33, No. 10, 550-554 (1952) Oct.

Discusses the metallurgical, chemical and mechanical problems involved in constructing vessels capable of withstanding high pressure and vacuum, high temperature and corrosion for the chemical industry. Welding, stress relieving, corrosion and testing are reviewed. Most difficult of all clad materials to weld to X-ray requirements is nickel-clad plate. G. A. Harvey and Co. and Lukens Co. have reached perfection in the welding of nickel-clad plates. Experiences with unusual fabrication tasks as in nitric acid plant, high vacuum vessels, tubular heat exchangers, removable covers, high-temperature plant and vacuum fractionator are considered. Photographs.—INCO. 5500

8.8.1, 3.7.3

Chemicals from Milk. M. L. KASTENS AND F. A. BALDAUSKI. Sheffield Farms Co., Inc. *Ind. and Eng. Chem.*, 44, No. 6, 1257-1268 (1952) June.

Corrosion problems are encountered



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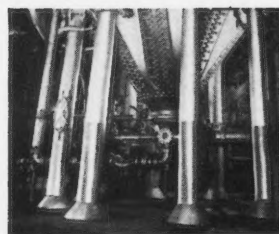
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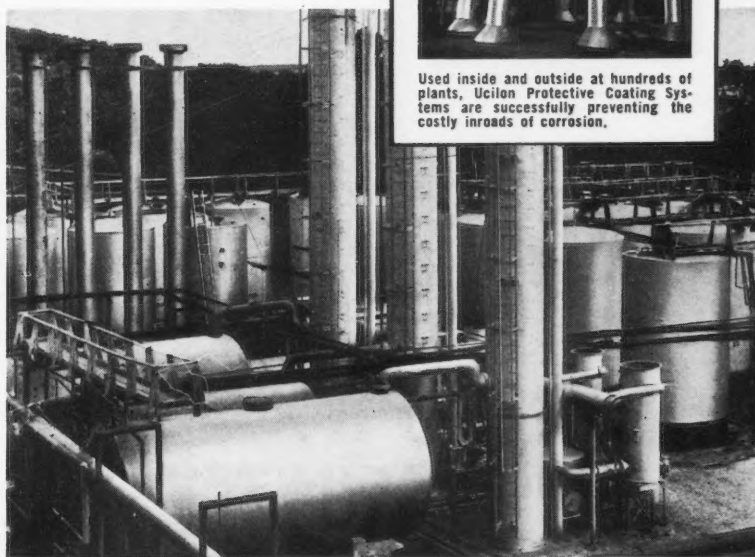
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in milk by-product recovery. The milk whey is mildly corrosive because of the lactic acid. Other corrosion problems are intensified by the addition of hydrochloric acid in processing the casein and the accumulation of salts during the processing of lactose. In the sugar plant, the evaporators are made of Type 304 stainless steel throughout. The centrifuge bowls for the crude sugar recovery are of bronze, but the refined centrifuge is of stainless. Slurries are removed by Duriron pumps. Weldless stainless steel pipe and fittings and glass-lined and stainless steel vessels are used where contact is made with solutions of protein hydrolyzates, which are very corrosive.—INCO. 5522

8.8.1, 6.2.5

The Chemical Industry Can Extend

Applications. *Metal Progress*, 62, 113-114 (1952) Sept.

Three short articles on straight-chromium stainless steels: Chemical Industry's Experience is Reasonably Satisfactory, L. R. Honnaker; Does Not Contaminate Mildly Corrosive Solutions, M. H. Brown; and Gives Adequate Service in Nitric Acid and Ammonia Plants, R. A. Byorum.—BTR. 5529

8.8.1, 4.4.10

Formaldehyde from Methanol. R. N. HADER, R. D. WALLACE AND R. W. McKINNEY. *Spencer Chemical Co. Ind. and Eng. Chem.*, 44, No. 7, 1508-1518 (1952) July.

Discussion of the commercial method of preparing formaldehyde by using methanol. To minimize corrosion problems, Spencer has made extensive use

of stainless steel throughout its plant. All lines with which formaldehyde comes into contact are made of stainless steel, usually Type 347. In the working parts of pumps and valves, Types 316 and 347 are used. Other materials include rubber-lined steel, acid-resistant enamel and stainless-clad steel. Illustrations and references are included.—INCO. 5544

8.8.1, 4.4.2

Lactic Acid from Corn Sugar. G. C. INSKEEP, G. G. TAYLOR AND W. C. BREITZKE. *Ind. and Eng. Chem.*, 44, No. 9, 1955-1966 (1952) Sept.

Production of lactic acid from corn sugar. Stainless Type 316 is used for acid evaporators, vacuum filters, heat transfer coils in the fermentors and processing tanks and for circulating and processing pumps. Wood is used as a satisfactory material for constructing the fermentors. The calcium lactate evaporator is equipped with copper tubes and a bronze alloy vapor head. Graphs, tables and 34 references.—INCO. 5552

8.8.1, 7.6.1

Material Problems in Chemical Process Equipment. L. PIATTI. Paper before Schweizerischer Verband für die Materialprüfungen der Technik, Zurich, May 20, 1950. *Sulzer Tech. Rev. (Switzerland)*, No. 1, 21-34 (1952).

Describes the principal forms of corrosion, such as galvanic, concentration cell, intercrystalline, fretting, caustic embrittlement, cavitation erosion, pitting and scaling, in the light of practical experience and indicates the respective remedies. All materials used for process equipment should be carefully selected by the chemist and engineer with due regard to the service conditions and chemical reactions involved, while considered attention should be paid to questions of design and manufacture. Use of austenitic chromium-nickel steels which are available to the process equipment builder is cited. Photomicrographs and graphs.—INCO. 5663

8.8.5

Preventing Corrosion in the Plating Shop. *Electroplating & Metal Spraying*, No. 10, 335-336 (1952) Oct.

Need for protection of steel work and floors in plating shops. The new vinyl resins or synthetic rubber solutions are suggested for the protection of steel work with the procedure for application given. For flooring, bricks and tiles set in acid-resisting cement were found satisfactory.—INCO. 5693

8.9 Group 9

8.9.2

The Finishing of Motor-Car Bodies. A. A. B. HARVEY. Paper before Sheet & Strip Metal Users' Tech. Assoc. Spring Mtg., London, April 13, 1952. *Sheet Metal Inds.*, 29, No. 301, 451-458 (1952) May.

Cleaning, phosphate coating by spray or by immersion, application of primer, material for body finishing either lacquer or enamel and operations subsequent to priming are discussed.—INCO. 5567

8.9.2, 7.1

Some Things to Know About Picking Mufflers. H. A. WIEDENMAN AND M. D. PUGH. *Diesel Power*, 30, No. 5, 59-61 (1952) May.

Mufflers are used to reduce or smooth out the pulsating flow which is the cause



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of noise. Nature of the problem, muffler types, materials, spark arrester-silencers and installation suggestions are considered. There are five types of mufflers. Most mufflers are made from ordinary mild steel. Stainless 18-8 steel is used for installations where corrosion-resistant qualities are needed and where high exhaust temperatures are encountered. Some mufflers are now being made using 430 non-nickel-bearing stainless steel, and some manufacturers are coating mild steel with a ceramic coating.—INCO. 5843

8.9.2, 1.7.2

Car Finish Tests in Florida. *Paint Manuf.*, 22, No. 4, 137-138 (1952).

The paint testing stations of an American car manufacturer are described. Apparatus is set up in Florida to measure the amount and intensity of sunlight and the time for which surfaces are wet with rain or dew. In Michigan salt used to thaw icy pavements is considered to cause corrosion of cars; the addition of rust inhibitors to the salt is now being investigated.—RPI. 5725

8.9.3, 8.4.2

Network of Pipe Lines Serves Old Ocean Field. *W. F. ROSE. Oil Gas J.*, 51, No. 23, 186-188 (1952) Oct. 13.

Internal corrosion of the gas-condensate gathering lines, believed to be related to hydrate formation is observed in the lower half of the pipe line. It results in a loss of wall thickness on the ground side and eventually in the forming of a longitudinal rupture. As a preventive, chemical gravity feed treaters were installed at the gas wells. As a

further precaution, the pipe is surveyed with a wall-thickness tester which detects internally corroded areas by an acoustic mechanism.—INCO. 5751

8.9.3

Longest, Largest Line Laid in Galveston Bay. *FRANK H. LOVE. Petroleum Engr.*, 24, D3-D6 (1952) Feb.

Construction of pipeline, including coatings for protection against marine attack and welding procedure.—MR. 5589

8.9.4, 5.4.5

Hot Spray Results. *Ind. Finishing (U.S.A.)*, 28, No. 6, 67-68 (1952) April.

A brief note on the excellent results obtained on steel freight cars from the use of a finish consisting of a synthetic zinc chromate primer with 12½% solvents, plus one coat of a synthetic red enamel sprayed on hot. After three years of continuous service the two-coat system showed "added advantages of color and gloss retention and exceptional durability."—ZDA. 5546

8.9.4

Investigation of the Formation of Black Stains on the Running Surfaces of Rails. (In German.) *WALTER JANICHE. Stahl und Eisen*, 72, 758-765; disc. 765-766 (1952) June 19.

Discusses causes of above by accumulation of corrosion products in the depressions. Stained rails were examined to determine influence of non-metallic inclusions and rupture at the edges due to excessive loads.—BTR. 5694

8.9.4, 6.4.2, 2.2.4

Unpainted Car for Underground. *Light Metals (England)*, 15, No. 172, 216, (1952) July.

A complete train in unpainted aluminum will appear in the London underground service later this year. At the present time one car is in service, the traditional red paint of the London underground being absent except a 3-in. band below the windows and in the name transfers. If the unpainted aluminum surface wears well enough, the initial finishing coats and maintenance will be practically removed.—ALL. 5595

8.9.5, 3.5.12, 4.6.11

Effect of Colour on Marine Growth on Ships' Bottoms. *M. RAGG. Farbe u. Lack*, 58, No. 10, 435-440 (1952).

Laboratory tests and open-sea trials are reviewed in detail. Recent long-term experiments confirmed that green has the optimum inhibiting effect and that red promotes marine growth. So far it has not been possible to develop non-toxic anti-fouling compositions based purely on the color effect.—RPI. 5740

8.9.5, 3.5.8

Improving Crack Resistance in Ships. *F. JONASSEN. Marine Eng. and Shipping Rev.*, 57, 67-68 (1952) Oct.

Since it is not known whether the present requirements for the construction of welded ships are sufficient to prevent structural failures, it may be well to consider further improvements to increase the crack resistance of ships. A number of such improvements are known and they can be instituted now in spite of lack of knowledge of quantitative requirements for notch toughness. Some of these are as follows: 1) Normalizing, particularly for the heavier plate thicknesses. 2) Reducing the strength requirement of ship-building steel by lowering carbon content; such

a change will produce a tougher and more weldable steel. 3) Specifying the use of only killed steel for the mid-length of the ship or at least for the known critical areas of this portion of the ship. As mentioned earlier additional improvements of steel quality result from the use of reduced carbon and increased manganese content, fine grain practice and normalizing. 4) Requiring subsurface inspection of welds, at least of welded butts in critical areas of the ship. 5) Specifying the use of low-hydrogen electrodes. 6) Modifying designs to reduce scantlings, thereby reducing plate thickness wherever possible will also add to the notch toughness of the structure. 7) Eliminating bulb shapes since sound butt welds are difficult to make in these shapes. The improvements proposed in the foregoing cannot, of course, be applied to existing vessels. However, remedial measures have been devised for ships in this category. These consist of riveted crack arrestors which represent the best solution now available for the protection of large all-welded steel structures. These crack arrestors have proved effective in halting a number of fractures, thereby undoubtedly preventing some ships from breaking in two. If, however, the load on the hull is sufficiently high, it is of course realized that these crack arrestors cannot maintain the integrity of the structure, particularly when the fractures have become extensive. It is noted that ships fitted with crack arrestors have broken in two.—TIME. 5643

8.10 Group 10

8.10.2

Properties of Steels Refined in the Converter by Blowing Pure Oxygen from the Top. (In German.) *HUBERT HAUTTMANN. Stahl und Eisen*, 72, 1011-1018, disc. 1019-1024 (1952) Aug. 14.

Results of comprehensive tests on 12 test melts of variable composition. Tensile and impact strength, weldability, cupping, corrosion resistance, electrical properties and magnetic properties were studied. Numerous graphs and tables.—BTR. 5695

8.10.3, 2.3.7

Mechanical-Metallurgical Problems Associated with Mine Drilling Operations. *T. W. WLODEK. Can. Mining Met. Bull.*, 45, No. 487, 651-657 (1952) Nov.

Field performances of the bit, attachment, drill rod and shank end elements in the drill set are analyzed and their service lives are compared. Common causes of service failure are reviewed and possibilities of increasing service life are discussed. Laboratory methods now employed for the simulated service testing of tungsten carbide bits, conical push-on and threaded types of attachments, drill steel rods and shank ends are described. Fretting corrosion, corrosion-fatigue and water corrosion are considered. Illustrations and references.—INCO. 5821

8.10.5

Animal Glue. *W. Q. HULL AND W. G. BANGERT. Ind. and Eng. Chem.*, 44, No. 10, 2275-2284 (1952) Oct.

In the production of animal glue, the rotary extractor is constructed of steel, digesters are of boiler plate with a false bottom of carbon-steel and leaf filters are of stainless steel. 15 references.—INCO. 5548

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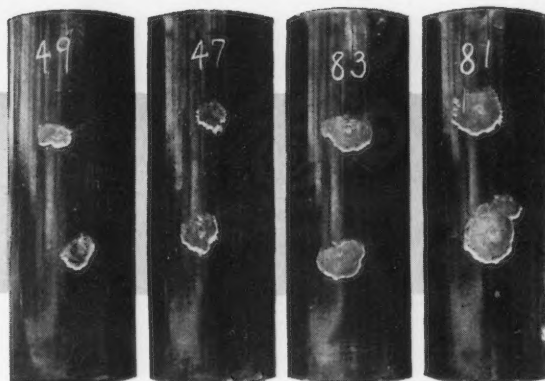
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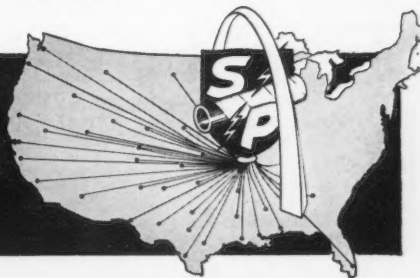
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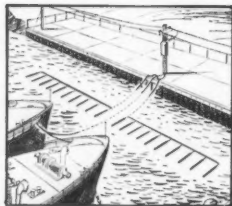
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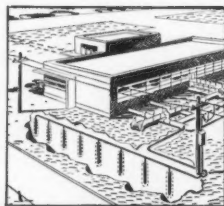
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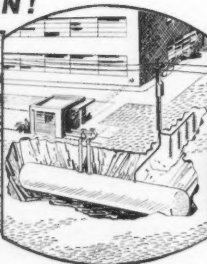
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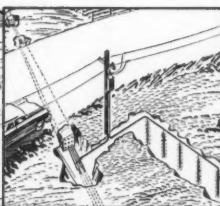
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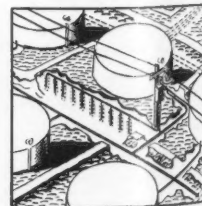
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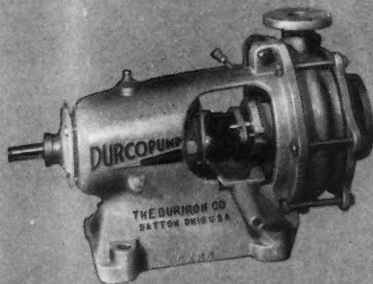
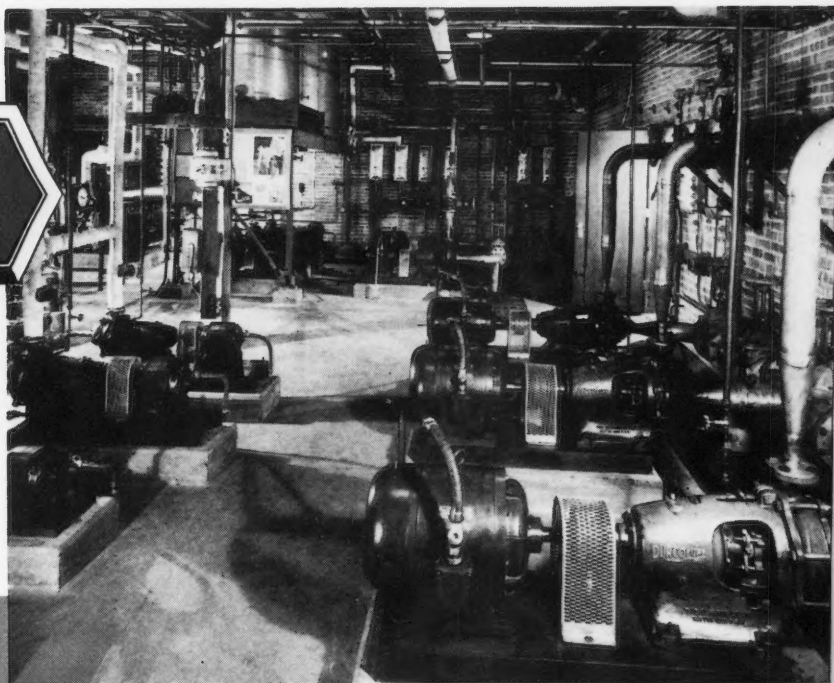
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